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OF THE

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VOL. VI.

1853-55.

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DIRECTIONS TO THE BINDER.

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GEOLOGICAL SOCIETY OF DUBLIN.

VOL. VI. 1853–4. PART I.

November 9th, 1853.—"On the Newer Palæozoic Rocks, which border the Menai Straits, in Carnarvonshire;" by the Rev. SAMUEL HAUGHTON, A. M., Professor of Geology in Trinity College, Dublin.

THE newer palæozoic rocks, in Carnarvonshire, occur on the east side of the Menai Straits, where they form a thin patch, extending N. E. for a distance of upwards of $8\frac{1}{4}$ miles; their greatest breadth, measured in the N. W. direction, being less than one mile. They are bounded on the south-east by one of those bands of felspar porphyry which constitute so remarkable a feature in the geology of north-western Wales, and on the north-west by the Menai Straits.

I have selected this district for examination from the fact of its appearing to contain a complete series of deposits, extending from the upper Devonian sandstones and conglomerates on the north, to the shales and marl beds of the coal measures on the south; thus affording, on a small scale, a section of the Welsh deposits which correspond to the Devonian sandstones and carboniferous limestones which occur on so much larger a scale in our own country.

I have endeavoured to ascertain with some degree of accuracy the thickness of the various beds composing this district, and have carefully recorded the position of the numerous fossils with which the limestone beds abound.

The measures obtained for the beds connecting the upper Devonian sandstones with the lower Carboniferous limestones I consider to be satisfactory and accurate; but the relations existing between the limestone and the coal shales resting upon it are more obscure, and with reference to this part of my Paper, I do not feel quite so confident in the accuracy of my measurements.

With the view of elucidating the structure of the newer palæozoic beds to the east of the Menai Straits, I have also examined the western shore of the Straits, where the same or a similar series of beds occurs, and I have found the conclusions drawn from the examination of the eastern shore fully borne out by the observations made by me on the corresponding beds of the western side of the Menai; but as I had not an opportunity of following the latter inland, I have not thought fit to include the palæozoic rocks of Anglesey in my description, but have contented myself with using the latter to corroborate the observations made on the structure of the former.

For the convenience of description I shall divide my subject into the following parts: a sketch of the physical geology of the district; the details of measured thicknesses of beds; the fossils characteristic of each; and a few deductions which appear to be naturally suggested by the observed facts.

PHYSICAL GEOLOGY OF THE DISTRICT.

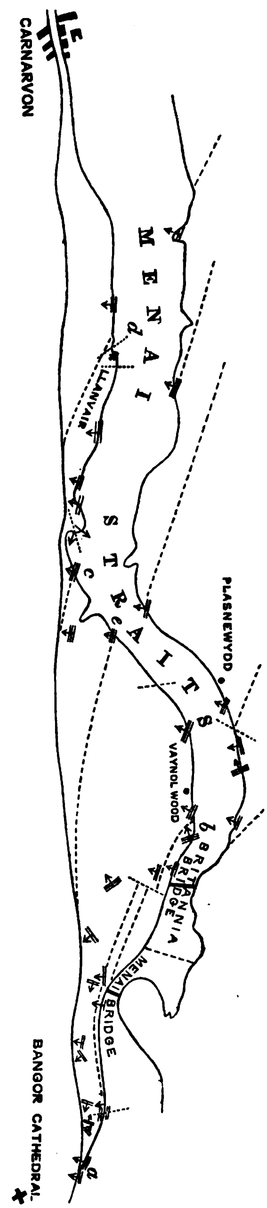
The eastern, or rather south-eastern, boundary of the district is nearly a straight line of fault, which is traced on the map of the Geological Survey. The total length of this line, which bears E. 47° N., is 8·46 miles, of which about $1\frac{1}{4}$ miles on the north is bounded by metamorphic slate and conglomerate; the remaining $7\frac{1}{4}$ miles being bounded by felspar porphyry containing quartz crystals (Eurite), which terminates abruptly on the south in Twthill, near Carnarvon. This rock is locally called granite, and it is almost deserving of the title, as it is nothing but a granular compound of felspar and quartz in about equal proportions, distinctly crystallized; it preserves its texture pretty uniformly, excepting that it is finer and more compact in the northern portion, and is the most quartzose of all the bands of felspathic rock which intersect Carnarvonshire from N. E. to S. W.

The western boundary of the newer palæozoic district extends

from Russell's oyster beds, near Bangor, on the north, to the town of Carnarvon on the south. The total length of this line is 9·35 miles.

On the western shore of the Menai, the newer palæozoic rocks extend from a point less than half a mile west of Britannia Bridge to the southern extremity of the Straits. The northern boundary may be fixed on a map by the observation that the house in Vaynol Wood bears from it S. 30° W. (Mag.)

An inspection of the accompanying outline Map will show that on the western boundary the general strike of the beds coincides with the line of coast, with the exception of the part contained between the Menai Bridge and the point marked (*c*). From the Menai Bridge to the point (*b*) there is a slight deviation of the strike from the coast line, so as to expose (neglecting faults) beds successively older; while from the point (*b*) to the point (*c*) the deviation is such as to show beds successively newer: it will be also perceived from the map, that this is owing to the change in direction of the coast line, and not of the line of strike, which is very constant along the whole coast, and in its average direction is nearly W. 26° S., i. e. mag. E. W. In going inland, the line of strike is considerably disturbed, particularly near the eastern boundary and northern extremity of the district, where it is



frequently thrown into a direction at right angles with the average direction.

The explanation of the fact just mentioned is one of the problems of the district, which appears to me to be fully elucidated by the trap dykes and secondary faults, which I shall now proceed to describe.

Trap Dykes.—The district under examination is intersected by three systems of trap dykes, which occur at the following points, and with the following bearings:—

1. At a point half a mile west of Russell's oyster beds, two dykes of highly crystalline trap occur, composed of well-developed crystals of felspar and augite, and weathering into nodular masses of a greenish-brown clay; these dykes are nearly vertical, and intersect the cliff from top to bottom, cutting and altering the blue limestone in a quarry at the top into a crystalline marble, and changing the arenaceous beds at the bottom into a hard siliceous slate. The northern dyke is 14 feet wide; and the breadth of the whole system, measured at the top, is 106 feet.

The northern dyke bears E. 40° S., and if produced would pass under the farm-house in Nant y borth. It will be seen by the Map that the line of its prolongation would cut the eastern boundary at a point where the limestone and conglomerate beds are greatly disturbed.

2. The second dyke occurs at a point a quarter of a mile south of the point opposite Plas Newydd; it is very much decomposed, but appears to be identical in composition with the first dyke, and alters in a similar manner the limestone intersected by it.

It bears E. 35° S.

3. The third series of dykes occurs at the church of Llanvair-isgaer, and consists of a number of dykes which intersect and alter, in a remarkable manner, a red, loose conglomerate which occurs at this point, dipping at a small angle inland. The principal of these dykes are laid down on the map.

The dyke south of the church is 8 feet wide.

The most northern dyke is 5 feet wide, and bears S. 45° E.

Between these two dykes occur a number of thin veins of trap, about one foot wide, which intersect the conglomerate in various directions, and change it into a gray, flinty conglomerate.

A minute description of these trap dykes, and of the alterations produced by them in the red conglomerate, was read before this Society, by Mr. Trimmer, in 1838, and is printed in our Journal, vol. ii. p. 35.

The parallelism and similarity of texture of these three systems of trap dykes is remarkable; and it is also to be observed, that their mean direction, E. 40° S., is almost perpendicular to the direction of the porphyritic band which bounds the district on the east.

Faults.—The faults in the northern end of the district are very numerous, although they do not appear to have produced much disturbance in a vertical direction. Those whose bearing I was able to ascertain are here given:—

1. There is a vein of sulphate of barytes, containing a little galena, in the North Swilly rock, in red micaceous slate, from 1 inch to 5 inches wide. This vein bears S. 26° E. (N. S. mag.)

2. In the railway cutting near the Britannia Bridge there are four faults, which bear as follows:—

1. Bears,	. . . . . .	E. 4° S.
2. „	. . . . . .	S. 16° E.
3. „	. . . . . .	S. 4° W.
4. „	. . . . . .	S. 16° E.

The first and third of these are at right angles, and the second and fourth are parallel.

3. On the Anglesey shore, at one-third of a mile north of Plasnewydd, there is a slight fault, which bears S. 16° E.

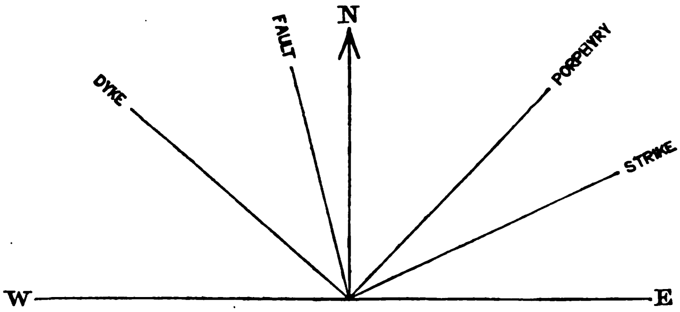
Rejecting the first of the second system, as belonging to the perpendicular group of faults, we find the mean direction of faults to be S. 14° E.

The mean of twenty-four measurements of the strike of the beds of limestone and sandstone through the whole of the undisturbed part of the district gives E. 27° N. mag. E. W. nearly. Consequently, the average direction of the faults makes an angle of 77° with the average direction of the strike.

It has been already shown that the average direction of the trap dykes makes an angle of 87° with the average direction of the porphyritic dyke, which is well represented by the eastern boundary of the palæozoic rocks.

The relations between the lines of strike and fault, and the di-

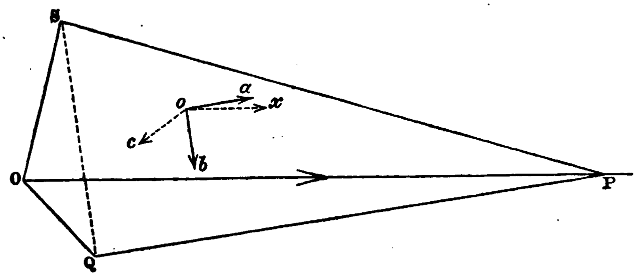
rections of the porphyry and trap dykes, are shown in the accompanying diagram. These relations appear to me to admit of explanation on physical principles, and to throw light on the structure of the entire district.



The band of porphyry is clearly of an age much earlier than the palæozoic rocks under consideration: this is shown by its parallelism to the other porphyritic and syenitic bands of North Wales, and to the line of strike of the Cambrian rocks which border its eastern side. The newer palæozoic beds dip towards the porphyry band, and appear to have been originally deposited quietly upon its western slope. Some cause or combination of causes—either alteration of relative level, or lateral pressure, or a combination of both—gave to these beds a slight dip towards the south-eastern side, and a line of strike making an angle of 20° with the band of porphyry. This line of strike is shown by the figure to lie to the south of the porphyry band. A series of trap dykes, making an angle of very nearly 90° with the porphyry, intersected and thrust upwards the palæozoic beds; and it is to the action of these dykes we must attribute the faults which are found in the latter.

The direction of the porphyry band, and the line of strike of the palæozoic rocks, are to be admitted as ultimate facts. The perpendicularity of the trap dykes to the porphyry is a fact quite in accordance with the known laws of volcanic action; and the fact to be explained is, the direction of the lines of fault consequent on the conditions supposed. If the strike of the beds were parallel to the porphyry dyke, the action of the trap dykes would be to rend the beds in a direction either parallel to the line of dip or of strike. In the case we are considering, the line of strike makes an angle of 20°

with the porphyry; and the effect of the intrusion of trap dykes perpendicular to the latter is to produce a series of faults, not perpendicular to the porphyry, but making with it an angle of 57°,—the perpendicular being, as it were, pushed towards the line of porphyry.



In the annexed figure, let OPS denote a horizontal plane, OP the bearing of the porphyry band, OS the trap dyke at right angles to it, PSQ the plane of a limestone or other bed, the point Q being vertically under the point O; SP is the line of strike, making an angle of 20° with the line OP. The intrusion of the trap dyke in the plane OSQ produces, on the whole, a lateral pressure on the bed SQP, acting in a direction parallel to OP, or perpendicular to the plane of the dyke. This lateral pressure *ox* at any point *o* of the plane SQP may be resolved into three directions at right angles to each other: *oa* parallel to QP; *ob* perpendicular to QP, and lying in the plane of the bed SPQ; and *oc* perpendicular to the plane SPQ. The effect of the forces *ob* and *oc*, which lie in the plane perpendicular to the line QP, will be to turn and bend the plane SPQ round the line QP, and to break it in directions parallel to QP and *ob*, which is perpendicular to QP; but it can be shown by mechanical considerations* that the effect of the forces parallel to *oa* will be to shift the lines of fracture to the right, and give the plane SQP a tendency to break in two directions,—one lying inside the angle SQP, and the other at right angles to it: but the angle SQP is less than 90°, and therefore the angle made by the line of fault will *a fortiori* be less than 90°. The effect of the lateral force *oa* will be different at different parts of the bed or plane SPQ. In the investigation contained in the note I have endeavoured to show,—

* See Note at end of Paper.

1st. That at very great distances from the line QP its effect will not be sensible in distorting the line of fracture, but that it will conspire with the forces *ob* and *oc* to break the bed in a direction at 90° with QP. 2ndly. That at points situated very near the line QP, the effect of the lateral forces *oa* will be to shift the line of fracture to the right through 45°, so that the bed will tend to break along a line making with QP an angle of 45°. And 3rdly. That its effect at intermediate points will be intermediate; or, in other words, that the line of fracture will lie between 45° and 90°; approaching the former as the point considered lies nearer to QP, and approaching the latter as it lies at a greater distance.

The actual directions of the faults observed range from 39° to 69° with the porphyry dyke, and the mean of the whole is 57°. This may be considered as a sufficient confirmation of the theory, when we consider the multitude of disturbing causes unknown to us (such as the peculiarities of direction and pressure of each dyke, and local varieties of composition and strength in the beds fractured), which have been necessarily omitted in the theory, and which undoubtedly exert an influence upon the phenomena observable in the field.

On the whole, I am inclined to consider the features exhibited by the physical structure of the district under consideration to be explicable on known mechanical principles; and though I may have erred in some of the inferences I have drawn, and possibly a simpler and more complete account of the phenomena might be given, yet I have the utmost confidence in the principles on which I have endeavoured to explain the facts, and wish to express my conviction that the attention of geologists must sooner or later be directed to the necessity which exists of removing from physical geology the reproach of vagueness and looseness of expression which has been often made against it, by more exact observation of the facts of physical structure of the beds which are constantly presented to our notice in disturbed districts.

It has been supposed, in the foregoing inferences, that the beds were held fixed by the porphyry dyke, and it is on this supposition that I have drawn the conclusion that near that dyke the angle made by a fault would probably be 45°. If, however, as appears to have actually occurred, the beds should slide or slip along the porphyry dyke, in consequence of the lateral pressure; the second in-

ference drawn above will require to be modified, and the angle made with the porphyry dyke will be less or greater than 45°, according as the compression of the beds parallel to the porphyry dyke is less or greater than the compression perpendicular to that dyke.

MEASUREMENTS OF THICKNESS OF STRATA.

I shall describe the details of the measurements of the strata, commencing from the N.E. point at Russell's oyster beds, and proceeding in a south-westerly direction along the shore of the Strait.

About 200 yards S.W. of Russell's house the *first fault* occurs, the direction of which I was unable to ascertain further than that it slopes towards the porphyry dyke in the same direction as the other beds of the district.

To the eastward of this fault may be observed the following series of beds:—

I.—*Section N.E. of Fault near Russell's House.*

	Feet.
1. Gray shale,	3
2. Brown shale,	2
3. Red and purple slaty marls,	5
4. Brown and yellow sandy shale,	2
——— (*Top of Cliff.*)* ———	
5. White sandstone conglomerate, containing angular fragments of red flint,	15
6. Brown shaly limestone,	14
7. Dark and purple marls, with nodular beds in centre,	8
	49

If the beds Sect. I. 6, 7, represent the beds Sect. III. 1, 2, and Sect. IV. 1, 2,—which I consider not improbable (from the fact observed in Nant y Borth, that the conglomerate rests immediately on a blue crystalline and nodular limestone),—then this fault will be accompanied with a down-throw to the N. E. of about four feet.

The bed No. 5 is very characteristic of this section, and may easily be recognised by the occurrence of the peculiar red flinty pebbles. I observed this bed to occur in two places inland, in Nant y Borth, which are marked on the map; and in one of these places the conglomerate is seen to lie over the beds of limestone;

* The horizontal line drawn through this section denotes the same physical level as the corresponding line, Sec. II.

from which circumstance, coupled with the section south of Russell's house, No. II., I infer that at this fault the down-throw is on the N.E.

II.—*Section S. W. of Fault near Russell's House.*

	Feet.
1. Coarse blue crystalline limestone,	6
2. Calpy blue limestone and shale,	7
3. Gray sandy limestone, containing *Producta gigantea*,	3
4. Dark and purple shale,	6
5. Nodular limestone, resting on red marl,	7
(*Top of Cliff.*)	
6. Blue crystalline marble,	1
7. Brown shaly limestone, containing other beds of blue marble, one foot thick,	26
8. Yellow, black, and brown calcareous shale,	17
	73

The beds, Sect. I. 4, 5, are identical with Sect. III. 6, 7, 8, and Sect. IV. 5.

At the system of trap dykes north of the George Hotel, which has been already described (p. 4), the *second fault* occurs, accompanied with a down-throw to the N.E. amounting to 19 feet; this may be seen from the following sections, which are taken at opposite sides of the fault:—

III.—*Section N. E. of Trap Dykes near George Hotel.*

	Feet.
1. Coarsely crystalline compact limestone, containing *Productus giganteus*, var. *Scoticus*,	17
(*Top of Cliff.**)	
2. Black and yellow marl,	4
3. Nodular limestone and red marl,	6
4. Blue crystalline limestone, altered by trap dyke, and containing *Productus giganteus*,	14
5. Thinner beds of do. do.,	6
6. Purple marl,	4
7. Nodular limestone,	3
8. Purple and greenish marl,	4
	58

* The horizontal line in this section corresponds to the top of the cliff, and denotes the same physical level as the line in Sec. IV.

The beds, 6, 7, and 8, of this section are identical with Sect. II. 4, 5, and Sect. IV. 5.

In the cliff and quarry S. W. of these dykes the following section was obtained:—

IV.—*Section S. W. of Trap Dykes near George Hotel.*

	Feet.
1. Crystalline and calpy blue limestone,	6
2. Yellow nodular limestone,	6
3. Compact crystalline blue limestone,	16
(*Top of Cliff.*)	
4. Thinner beds of do. do.,	11
5. Beds of red marl, with nodular limestone in the centre,	12
6. Compact and calpy brown limestone, passing into brown calcareous sandstone,	14
	65

The beds Sect. IV. 5 are identical with Sect. III. 6, 7, 8, and Sect. II. 4, 5; from which may be inferred that the alteration in level produced by these dykes is 19 feet, the down-throw being towards the N. E.

Proceeding along the Strait in a S. W. direction, we find the *third fault* about a quarter of a mile N. E. of the George Hotel. This fault is accompanied by a down-throw to the N. E., the amount of which I was unable to ascertain. In consequence of this fault, the beds of sandstone which underlie the limestone of the district appear in the cliffs, and occupy the place of the limestone, with scarcely any exceptions, for a distance of 2·19 miles, to the point in Vaynol Wood, where the limestone reappears, and afterwards continues for 3·88 miles, without interruption, to the church of Llanvair Isgaer, where, in its turn, the limestone is succeeded by the clay and marl beds of the upper Carboniferous formation.

The subjoined section shows the succession of beds exhibited in the cliffs between the George Hotel and the fault just mentioned.

V.—*Section N. E. of George Hotel.*

	Feet.
1. Brown shaly limestone, in beds about one foot in thickness, alternating with shaly beds,	15
2. Yellow sandstone and dark-coloured shales, alternating in one foot beds,	10
3. Dark-coloured arenaceous shales,	14
4. Soft uniform yellow sandstone, with numerous impressions of plants,	6
	45

The bed Sect. v. 4 is the same as Sect. vii. 3; and Sect. v. 1 is probably the same as Sect. vi. 3.

The *fourth fault* which I shall describe occurs at about 200 yards N. E. of the Menai Bridge.

The following sections were made at each side of it; from which, and the Table given p. 16, we may infer a down-throw to the N. E. of about 29 feet:—

VI.—*Section N. E. Side of Fault at Menai Bridge.*

	Feet.
1. Compact blue limestone,	6
2. Black and red marl,	5
3. Yellow calcareous sandstone,	1
4. Purple marl,	5
5. Brown arenaceous crystalline limestone, with occasional beds of nodular limestone and shale,	16
——(*High Water Mark.*)——	
	33

The horizontal line at the bottom of this section is on the same physical level as the corresponding line in Sect. vii.; and probably the bed Sect. vi. 3 is the same as Sect. v. 1, and Sect. vii. 3 the same as Sect. v. 4.

VII.—*Section S. W. Side of Fault near Menai Bridge.*

	Feet.
1. Yellow sandstone and black shale, alternating in beds about one foot thick,	12
2. Black shale	6
——(*High Water Mark.*)——	
3. Soft yellow sandstone and conglomerate, with numerous impressions of plants,	7
4. Dark-coloured shale and yellow sandstone, alternating; the sandstone beds being about one foot thick,	13
5. Yellow and white sandstone and conglomerate, with impressions of plants,	15
6. Purple marl,	Unknown.
	53

The bed No. 5 forms the foundation on which the pier of the first arch, east side of the Menai Bridge, is built.

At the back of the George Hotel, in the railway cutting, 9 feet above the roadway of the bridge, a compact blue limestone occurs, containing *Producta gigantea* and *Lithodendron sexdecimale;* its strike coincides with that of the beds composing Section vi., and its dip

is 40°. It is at a height of 103 feet above the bottom of Section VI.; and as the dip of the beds in Section VI. is much below 40°, if we assume 30° as the average dip, it is easy to calculate that we should add at least 56 feet of limestone beds to the top of Section VI.

Westward of the Menai Bridge the *fifth fault* occurs, near the house at the foot of cliff; it is very obscure, but probably accompanied with a down-throw to the N. E.

The following section was obtained with some difficulty at the waterfall to the west of this house:—

VIII.—*Section near Waterfall W. of Menai Bridge.*

	Feet.
1. Flaggy white sandstone,	10
2. Purple marl,	5
3. White sandstone and conglomerate, alternating with red shaly beds,	12
4. Soft purple slaty marl, containing pisolitic concretions of brown peroxide of iron,	19
5. Hard red sandstone and purple slate,	2
6. Soft purple slate,	4
7. Red sandstone conglomerate, containing reddish-coloured mica slate and quartz pebbles,	1
8. Purple slate,	10
	63

The beds Sect. VIII. 1 probably represent Sect. VII. 5.

The pisolitic brown hæmatite concretions, mentioned in No. 4, occasionally pass into a hard pisolitic red hæmatite ore, which at one point attains a thickness of more than two feet. The point where the ore appears to be most abundant may be found by the following observation: the bearing of the Marquis of Anglesey's pillar from it is N. W. (mag.).

The following analyses show the average composition of both kinds of ore:—

Analysis of Brown Pisolitic Hæmatite, Menai Straits.

	Per Centage.
1. Loss by ignition, being water, carbonic acid, &c.	10·36
2. Clay and silica,	37·16
3. Peroxide of iron,	49·36
4. Alumina,	Trace.
5. Lime,	1.76
6. Magnesia,	0·32
7. Loss in analysis,	1·04
	100·00

The above analysis shows that the per centage of metallic iron in the raw ore is 34·55, and that it would be in the roasted ore 38.54. If this were used as an ore of iron it would require a large amount of lime to be added, in consequence of the high per centage of silica.

Analysis of Red Pisolitic Hæmatite, Menai Straits.

	Per Centage.
1. Loss by ignition, being carbonic acid, &c.,	4·88
2. Clay and silica,	30·68
3. Peroxide of iron,	62·59
4. Alumina,	1·07
5. Lime,	0·67
6. Magnesia,	Trace.
Loss in analysis,	0·11
	100·00

This analysis shows for metallic iron a per centage of 43·81, which is somewhat greater than that of the brown clayey ore; but both of these ores would require a large addition of bases, in order to flux with advantage.

Near the Britannia Bridge the beds are dislocated by the *sixth* series of faults, which have been described (p. 5), as they occur in the railway cutting behind the bridge.

To the south of the bridge the following series of beds may be traced:—

IX.—*Section S. W. of Britannia Bridge.*

	Feet.
1. Nodular blue crystalline limestone, containing *Cyathophyllum fungites*, the highest bed visible in the quarry being about the level of the bottom of the tube,	7
2. Not seen,	69
3. Brown sandstone conglomerate, and yellow sandstone, with impressions of plants, in flaggy beds,	9
4. Compact massive brown sandstone conglomerate, and white sandstone, with impressions of plants,	16
5. Dark-coloured and purple slaty shales and marls, with some thin hard beds,	11
6. Coarse brown and white conglomerate, with impressions of plants, and thin dark-coloured shale partings, containing nodules of iron pyrites,	20
	132

The eastern pier of the bridge, next the water, rests on the conglomerate bed marked No. 6; and the bed Sect. IX. 3 is probably equivalent to Sect. VIII. 1 and Sect. VII. 5.

In the railway cutting behind the Menai Bridge occurs a series of beds, with a strike 16° W. of N., and dip 8° E. This direction of strike is within about 10° of being at right angles with the average strike of the district, and is parallel to the strike of the highly disturbed beds already described in Nant y Borth.

The following section was obtained in this railway cutting:—

X.—*Section, Railway Cutting behind Menai Bridge.*

	Feet.
1. Loose red sandy limestone, decomposing into a gravel,	21
2. Brown and pink arenaceous limestone, somewhat more compact,	26
3. Pink and reddish sandstone and conglomerate,	7
4. Red shale,	1
5. Grayish yellow arenaceous limestone,	1
6. Black and yellow shale,	3
7. Coarse pink and gray limestone, turning into sandstone conglomerate in lower beds,	16
8. Dark-coloured shale,	3
9. Coal, and impressions of plants,	0·4
10. Brown, pink, and red gritty limestones, with frequent beds of coarse siliceous conglomerate; or rather the limestone itself passes into and frequently becomes conglomerate,	37
	115·4

This section is remarkable for the occurrence of the conglomerate beds in the midst of pure limestone; and it should be observed that the same circumstance is observable in the disturbed beds of Nant y Borth, although the conglomerate of Nant y Borth is peculiar, and cannot be confounded with the pink-coloured conglomerates of this section: these latter resemble the conglomerates found in the limestones near Porth Dinorwig, which belong to some of the most recent beds of the district. The occurrence of four inches of coal, which can be burned, has led to erroneous speculation as to the probability of coal being found in the neighbourhood, and trials have been actually made near the Britannia Bridge, at the base of the limestone, in the upper Devonian beds, in consequence of the occurrence of large crushed stems of plants, resembling those found in the true coal measures.

The following section was obtained in the cutting immediately

behind the Britannia Bridge, and the beds measured in it overlie the top of the Section IX.:—

XI.—*Section, Railway Cutting near Britannia Bridge.*

	Feet.
1. Purple shale and nodular limestone,	5
2. Close-grained, fine, compact blue limestone,	5
3. Dark-coloured shale,	3
4. Bluish-gray limestone, massive,	8
5. Blue limestone and dark-coloured shale in thin beds, containing *Producta gigantea*,	4
6. Dark and purple marl,	3
7. Purple and greenish conglomerate and compact sandstone,	8
	36

The beds Sect. XI. 1, 2, are probably equivalent to Sect. IX. 1.

The series of sandstone conglomerates and shales described at the base of Section IX. continue in a S. W. direction as far as the wall marking the N. E. boundary of Vaynol Wood. About 150 yards beyond this wall, red and purple marls, interstratified with compact blue and nodular limestone, appear, and constitute near the centre of Vaynol Wood a low anticlinal undulation: these beds are very fossiliferous, and distinguishable from all other beds in the district. Beyond Vaynol Wood the bedding is concealed by shingle as far as the point opposite Plasnewydd; from which point to Porth Dinorwig it is clearly exhibited in the cliffs, and appears to have undergone no disturbance, with the exception of that caused by the trap dyke (p. 4), already mentioned.

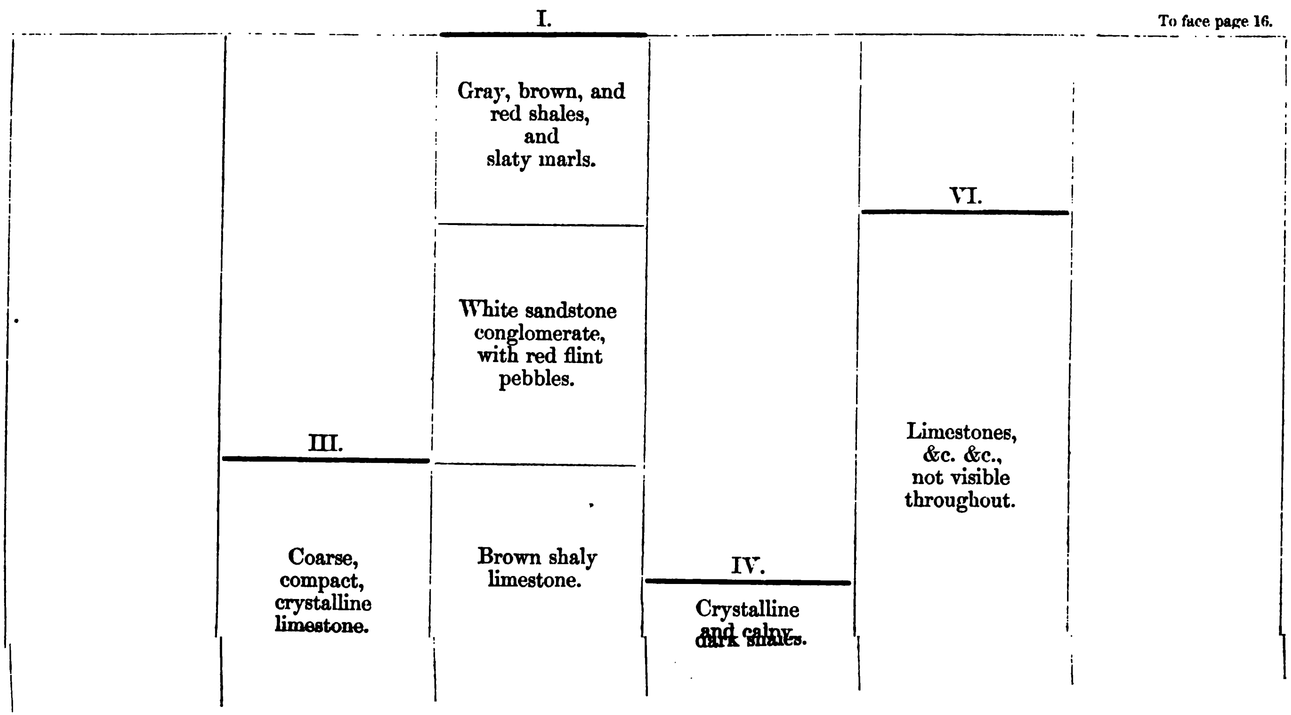
As the beds hitherto described are those in which the Devonian rocks appear, and as these rocks are not found further south, it will be useful to attempt from the sections already given to ascertain the total thickness of the lower beds in the northern part of this district.

The following general section, constructed on the scale of $\frac{1}{144}$th, exhibits the final result of all my measurements. Each section is numbered in it, and placed in its correct geological position; and the only section respecting whose place I have had any doubt is Section I.; but this I have placed, for the reason stated (p. 9), in the position it occupies in the general section; it appears to fit in accurately enough with Sections III., IV., and VI.:—

VERTICAL SECTIONS OF LOWER CARBONIFEROUS BEDS OF MENAI STRAITS.

SCALE = $\frac{1}{144}$TH.

To face page 16.



The total thickness of the beds contained in the foregoing Table is 204 feet, which may be deduced from the vertical columns; while horizontal lines drawn through the columns show the manner in which strata of the same geological age, but differing somewhat in lithological character, were deposited in different parts of the same basin.

The beds already described lie between the points marked *a* and *b* on the map (p. 3); and the lowermost of these beds, near the point *b*, are the oldest beds exposed in the district. From the point *b* to the trap dyke opposite Plasnewydd the beds are imperfectly visible, but are well seen from the trap dyke to the point near Porth Dinorwig, marked *c* on the map. Between these two points they are not broken by any fault, and dip steadily in the same direction, and with nearly the same angle of about 10° from the point *b* to *e*; from *e* to *c* the strike continues the same, but the dip is greater—from 20° to 25°.

From *b* to *e* the beds are composed of calpy yellowish and brown limestone and shaly deposits, which are very fossiliferous; one bed in particular, near the point *e*, north of Bryn Adda lime quarry, being formed almost altogether of the *Producta gigantea*, with a few varieties of *Astræa*, *Calamopora*, and *Lithodendron*. The direction of the coast line between the trap dyke and Bryn Adda makes with the strike an angle of 60°, the distance being 2596 feet. From these data, and the assumption that the dip is 10°, we can calculate the thickness of the beds to be $2596 \times \sin 60^\circ \times \sin 10^\circ = 390$ feet.

From the point *e* to *c* the lithological character of the beds is as follows:—In Bryn Adda quarry they are composed of pink and gray close-grained crystalline marble, containing *Lithodendra:* these marble beds are similar to those worked in Anglesey at the opposite side, near Llanedwen. Under these marble beds lie beds of red and pink nodular limestone, which form the upper part of the series from *b* to *e*. Between Bryn Adda and Porth Dinorwig occur two beds of pink coarse sandstone conglomerate; and near the Porth the limestone contains beds of pink chert. At the south side of the basin, near the railway station, the limestone becomes pink, gritty, and crystalline, occasionally conglomeritic and flinty. On the whole, these beds resemble strongly the beds in Section x., which lie over the beds described in the general section facing p. 16.

The average dip of all these beds is certainly over 20°, but I shall

Name.	Locality.	Irish Locality.	Irish Formation.
Zoophyta.			
1. **Astræa pentagona,** *Blainv.*	Porthdinorwig.	Largamore, Bangor, Mayo.	Y. S.
2. **Astræa basaltiformis,** *Conyb. & Phil.*	Vaynol Wood.	Tullyard, Armagh. Rathcline, Lanesborough, Longford. Galway and Queen's Counties. Cookstown, Tyrone. Bannaghaghole, Leighlin, Carlow. Raheendoran, Carlow.	Y. S. L. L. L. L. L. L. U. L. U. L.
3. **Lithodendron junceum,** *Keferstein.* *syn.* L. sexdecimale, *Phil.* L. coarctatum, *Portl.*	Vaynol Wood. Moel y Don.	Hook Point, Fethard, Wexford. St. John's Point, Dunkineely, Donegal. Poulscadden, Howth, Dublin. Cookstown, Tyrone.	Y. S. Y. S. Y. S. L. L.
4. **Lithodendron cæspitosum,** *Mart. sp.*	Moel y Don.	Soraghy, Castlederg, Tyrone. County Leitrim. Raheendoran, Carlow. Cookstown, Tyrone. Lough Gill, Sligo.	Y. S. L. L. U. L. L. L. L. L.
5. **Lithodendron irregulare,** *Phil.* *syn.* L. pauciradiale, *M'Coy.*	Bryn Adda.	Magheramore, Tobercurry, Sligo. Lough Gill, Sligo.	L. L. L. L.
6. **Cyathophyllum fungites,** *Goldf.* *syn.* Turbinolia fungites, *Flem.*	Ty Glo. Britannia Bridge. Vaynol Wood. Menai Bridge.	Kilbride, Ballycastle, Mayo. Hook Point, Fethard, Wexford. Bruckless, Dunkineely, Donegal. Slieve Gullion, Magherafelt, Derry. Lisnapaste, Ballintra, Donegal. Poulscadden, Howth, Dublin. Ballibodonnel, Dunkineely, Donegal. Malahide, Dublin. Termon, Boyle, Roscommon. Killala, Mayo. Lough Erne, Fermanagh. Ardagh, Drumcondra, Meath. Little Island, Cork. Lough Gill, Sligo. Cleene, Roscommon. Tralee, Kerry. Swanlinbar, Ballyconnel, Cavan. Belmore Mountain, Enniskillen.	Y. S. Y. S. Y. S. Y. S. Y. S. Y. S. Y. S. Y. S. L. L. L. L. L. L. L. L. L. L. L. L. L. L. L. L. M. L. U. L.
7. **Cyathophyllum turbinatum,** *Goldf.*	Vaynol Wood.		
8. **Cyathophyllum vermiculare,** *Goldf.*	Vaynol Wood.		
9. **Syringopora ramulosa,** *Goldf.*	Llanedwen.	Bruckless, Dunkineely, Donegal. Kilmore, Armagh. Malahide, Dublin. Killymeal, Dungannon, Tyrone. County Leitrim.	Y. S. Y. S. L. L. U. L. L. L.
10. **Syringopora geniculata,** *Phil.*	Vaynol Wood.	Drumscraw, Drumquin, Tyrone. Tinnycahill, Donegal. St. John's Point, Donegal. Malahide, Dublin. Armagh and Malahide. Clane, Kildare.	Y. S. Y. S. Y. S. Y. S. L. L. L. L.
11. **Syringopora catenata,** *Mart. sp.*	Ty Glo.	St. John's Point, Donegal. Unknown locality.	Y. S. L. L.
12. **Calamopora gothlandica,** *syn.* Favosites gothlandica, *M'Coy & Portl.*	Vaynol Wood.	St. John's Point, Donegal.	Y. S.
13. **Calamopora fibrosa,** *Goldf.*	Vaynol Wood. Bryn Adda.	Clonea, Dungarvan, Waterford. Curragh, Ardmore, Waterford.	Y. S. Y. S.

Name.	Locality.	Irish Locality.	Irish Formation.
Mollusca.			
14. **Orthoceras unguis,** *Phil.*	Llanedwen.	Clane, Kildare. Little Island, Cork. St. Doolagh's, Dublin. Black Lion, Enniskillen.	L. L. L. L. L. L. U. L.
15. **Bellerophon tangentialis,** *Phil.*	North Menai.	Horath, Moynalty, Meath. Drummanmore, Armagh. Lackagh, Drumquin, Tyrone. Drumscraw, Drumquin, Tyrone. Tirlechen, Ballymahon, Longford. Carlingford, Louth. Ardagh, Drumcondra, Meath. Clane, Kildare.	Y. S. Y. S. Y. S. Y. S. L. L. L. L. L. L. L. L.
16. **Bellerophon apertus,** *Sow.*	Bryn Adda. Llanedwen.	Ardagh, Drumcondra, Meath. Ballyduff, Dungarvan, Waterford. Annaghaigh, Armagh. Tankardstown, Kildorrery, Cork. Carlingford, Louth. Clane, Kildare. Roebuck, Dublin.	L. L. L. L. L. L. L. L. L. L. L. L. L. L.
17. **Euomphalus pentangulatus,** *Sow.*	Vaynol Wood. Bryn Adda.	Ring, Enniskillen, Fermanagh. Bruckless and Rahan's Bay, Donegal. Millicent, Clane, Kildare. Tirlechen, Ballymahon, Longford. Kilmalloch, Limerick. Little Island, Cork. Carrigahorrig, Portumna, Galway. Ballikea, Skerries, Dublin. Tankardstown, Kildorrery, Cork. Ardclough, Rathcoole, Dublin Bundoran, Leitrim.	Y. S. Y. S. L. L. L. L. L. L. L. L. L. L. L. L. L. L. L. L. M. L.
18. **Naticopsis.** *sp.*	Llanedwen.		
19. **Sanguinolaria curta,** *M'Coy, sp.*	Vaynol Wood.	Manor Hamilton, Leitrim.	M. L.
20. **Producta gigantea,** *Sow.*	Llanedwen. Ty Glo. Bryn Adda. Vaynol Wood.	Castle Espie, Comber, Down. Kiltullagh, Roscommon. Killymeal, Dungannon, Tyrone.	Y. S. L. L. U. L.
21. **Producta gigantea,** *Sow.* *var.* **Edelburgensis,** *Phil.*	North Menai.	Ardagh, Drumcondra, Meath. Cregg, Nobber, Meath. Ballyhea, Skerries, Dublin. Ballycastle, Antrim.	L. L. L. L. L. L. U. L.
22. **Producta gigantea,** *Sow.* *var.* **Scotica,** *Sow.*	Penmon.	Drumkeeran, Ederny, Fermanagh. Scraghy, Castlederg, Tyrone. Dromore, Omagh, Tyrone. Castle Espie, Comber, Down. Mullaghgliss, Monaghan. Little Island, Cork. Armagh, Armagh. Cookstown, Tyrone. Dundonagh, Monaghan. Ballintrillech, Bundoran, Donegal. Ballycastle, Antrim.	Y. S. Y. S. Y. S. Y. S. L. L. L. L. L. L. L. L. L. L. M. L. U. L.
23. **Producta hemisphaerica,** *Sow.*	North Menai. Penmon.	Kilmore, Armagh. Rush, Dublin. Lachagh, Drumquin, Tyrone. Lisnapaste, Ballintra, Donegal. Killelagh, Derry. Dundonagh. Little Island, Cork. Drumcondra, Meath. Ballintrillick, Bundoran, Donegal.	Y. S. Y. S. Y. S. Y. S. L. L. L. L. L. L. L. L. M. L.

Name.	Locality.	Irish Locality.	Irish Formation.
Mollusca—(*continued*).			
24. **Producta quincuncialis,** *Phil.*	Vaynol Wood.	Granard, Longford.	Y. S.
		Townparks, Killeshandra, Cavan.	Y. S.
		Hook, Fethard, Wexford.	Y. S.
		Malahide, Dublin.	Y. S.
		Little Island, Cork.	L. L.
		Rathcline, Longford.	L. L.
		Carnacarrow, Enniskillen.	L. L.
		Brownstown, Meath.	L. L.
		Tullyoran, Mohill, Leitrim.	L. L.
		Bundoran, Donegal.	M. L.
		Old Leighlin, Carlow.	U. L.
25. **Producta antiquata,** *Sow.*	Vaynol Wood. Ty Glo.	Lisnapaste, Ballintra, Donegal.	Y. S.
		Hook, Fethard, Wexford.	L. L.
		Ardclogh, Rathcoole, Dublin.	L. L.
		Millicent, Clane, Kildare.	L. L.
		St. Doolagh's, Dublin.	L. L.
		Carnacarrow, Enniskillen.	L. L.
		Manor Hamilton, Leitrim.	M. L.
26. **Orthis filiaria,** *Phil.*	Bryn Adda.	Bruckless, Dunkineely, Donegal.	Y. S.
		Howth, Dublin.	Y. S.
		Clonea, Dungarvan, Waterford.	Y. S.
		Malahide, Dublin.	Y. S.
		Boyle, Roscommon.	L. L.
		Howth, Dublin.	L. L.
		Finner, Bundoran, Donegal.	M. L.
		Abbey Bay, Ballyshannon, Donegal.	M. L.
		Old Leighlin, Carlow.	U. L
		Bannaghaghole, Leighlin, Carlow.	U. L.
27. **Orthis crenistria,** *Phil.*	North Menai.	Rahan's Bay, Dunkineely, Donegal.	Y. S.
		Cregganore, Gort, Sligo.	Y. S.
		Ardloughill, Ballyshannon, Donegal.	Y. S.
		Castle Island, Kerry.	Y. S.
		Edenassop, Tyrone.	Y. S.
		Hook Point, Wexford.	Y. S.
		St. John's Point, Donegal.	Y. S.
		Malahide and Howth, Dublin.	Y. S.
		Ardagh, Drumcondra, Dublin.	L. L.
		Brownstown, Meath.	L. L.
		Longford, Longford.	L. L.
		Carrigaline, Cork.	L. L.
		Tankardstown, Kildorrery, Cork.	L. L.
		Millicent, Clane, Kildare.	L. L.
		Bundoran, Leitrim.	M. L.
		Ballintrillick, Bundoran, Leitrim.	M. L.
		Black Lion, Enniskillen.	U. L.
28. **Atrypa fallax,** *Sow.*	Vaynol Wood. Dinas.	Ardoe, Ardmore, Waterford.	Y. S.
		Bruckless, Dunkineely, Donegal.	Y. S.
		Hook Point, Fethard, Wexford.	Y. S.
		Kilnamack, Clonmel.	Y. S.
		Currens, Castle Island, Kerry.	Y. S.
		Cregganore, Gort, Sligo.	Y. S.
		Howth, Dublin.	Y. S.
		Fivemiletown, Tyrone.	Y. S.
		Ballintrillick, Bundoran, Leitrim.	M. L.
29. **Martinia plebeia,** *Sow.*	Vaynol Wood.	Hook, Fethard, Wexford.	Y. S.
		Tullyard, Armagh.	Y. S.
		Lisnapaste, Ballintra, Donegal.	Y. S.
		Millicent, Clane, Kildare.	L. L.
		Ardagh, Drumcondra, Dublin.	L. L.
		Little Island, Cork.	L. L.
		Mullaghfin, Duleek, Meath.	L. L.
		St. Doolagh's, Dublin.	L. L.
		Cookstown, Tyrone.	L. L.
		Brownstown, Meath.	L. L.
		Armagh, Armagh.	L. L.
		Ballintrillick, Bundoran, Leitrim.	M. L.

NAME.	LOCALITY.	IRISH LOCALITY.	Irish Formation.
MOLLUSCA—(*continued*).			
Martinia plebeia—(*continued*).		Finner, Bundoran, Donegal. Black Lion, Enniskillen.	M. L. U. L.
30. **Reticularia lineata.** *Mart. sp.*	North Menai.	Doorin, Donegal. Rush, Dublin. Curkeen, Rush, Dublin. Little Island, Cork. Tankardstown, Kildorrery, Cork. St. Doolagh's, Dublin.	Y. S. Y. S. L. L. L. L. L. L. L. L.

Of the thirty fossils in the foregoing list, it will be observed that there occur in Ireland in the yellow sandstone group only, three fossils, viz.:—

Astræa pentagona,
Calamopora Gothlandica,
Calamopora fibrosa, . . . 3

In the lower limestone only, two fossils, viz.:—

Lithodendron irregulare,
Bellerophon apertus, . . . 2

In the calp only, one fossil, viz.:—

Sanguinolaria curta, . . . 1

In the yellow sandstone and lower limestone five fossils, viz.:—

Lithodendron junceum,
Syringopora geniculata,
Syringopora catenata,
Bellerophon tangentialis,
Reticularia lineata, ... 5

Four fossils range from the yellow sandstone to middle limestone, viz.:—

Euomphalus pentangulatus,
Producta hemispherica,
Producta antiquata,
Atrypa fallax, ... 4

Two range from lower to upper limestone, viz.:—

Orthoceras unguis,
Producta Edelburgensis, . 2

Two do not occur in Ireland, viz.:—

Cyathophyllum turbinatum,
Cyathophyllum vermiculare, 2

Carried forward, ... 19

Brought forward, ... 19

One is of undetermined species:—

Naticopsis, *sp.* 1

And ten range through the whole carboniferous epoch in Ireland, viz.:—

Astræa basaltiformis,
Lithodendron cæspitosum,
Cyathophyllum fungites,
Syringopora ramulosa,
Producta gigantea,
Producta Scotica,
Producta quincuncialis,
Orthis filiaria,
Orthis crenistria,
Martinia plebeia, ... 10

30

In the former part of this paper I have shown that the total thickness of the carboniferous beds in this district, excluding the supposed coal measures, is upwards of 1500 feet, of which the lowest and highest beds contain a quantity of sandstones, cherty, and conglomeritic deposits, indicative of shallow water; and there is reason to believe, that during the time of deposition of the entire group, land was not far distant, as is shown by the abundant remains of crushed stems and vegetable impressions found in the lower sandstones, and in the remarkable seam of coal found in the limestone (p. 15). This seam of coal appears to have been formed from drift-wood, as there is no sign of any "underclay," or other appearance usually supposed to indicate that the plants of which the coal is composed grew on the spot: they appear to have been drifted from the neighbouring land, and when sunk in the sea to have been rapidly covered up by the deposits of chemical and mechanical origin which succeed each other so often in this district. The circumstances under which the beds of this district were deposited were local, and have given rise to a peculiarity in the succession of strata, which renders it impossible to compare them individually with the typical beds of our Irish limestone.

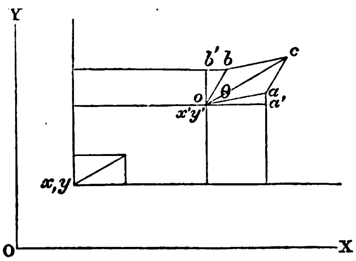
From a careful consideration of the fossils, and a comparison of them with Irish fossils of the yellow sandstone and carboniferous limestone series, I think, that although some of them are what some geologists would call Devonian, yet that there is, on the whole, no

sufficient reason for not considering them throughout as identical with carboniferous fossils. A comparison of these fossils with Gerolstein fossils, from the Eifel, in the Museum of Trinity College, shows a striking similarity in the Zoophytes, particularly the fossils named after Goldfuss, *Cyathophyllum turbinatum*, and *C. vermiculare.*

All the fossils found in the Menai Straits, with the exception of these two, are abundant in the lower limestone and yellow sandstone formations of Ireland; and the lithological character of the lowest beds, as given in the section facing p. 17, resembles strikingly the corresponding character of the arenaceous and conglomeritic beds, by which the lower limestones of Hook Point, and other characteristic Irish localities, pass by yellow and white sandstones, grits, and shales, downwards into the typical old red sandstone conglomerate.

The general conclusion which I think may be fairly drawn from the Menai group of rocks and fossils is, that in this district there exists no distinction between Devonian and Carboniferous deposits; but that the entire series of beds, including the red sandstone conglomerates and yellow sandstones at its base, must be considered as a continuous whole, and corresponds in its palæontological character with the lower limestone and yellow sandstone formations of Ireland.

Note to p. 7.—Let the plane of the rectangular axes OX and OY be the plane of the bed, the line OX being parallel to QP (p. 7); and let there be any small rectangle, whose corner is situated at the point x, y previous to the disturbance of the bed by the intrusion of the trap dyke. After the disturbance, by forces in the plane of the bed, let x', y' be the point which was before x, y, and let the parallelogram *oacb* be the figure assumed by the distorted rectangle. Then, if—



$$x' = x + \xi$$
$$y' = y + \eta,$$

it is easy to see the following relations:—

$$oa' = \frac{dx'}{dx}\,dx \qquad aa' = \frac{dy'}{dx}\,dx$$
$$ob' = \frac{dy'}{dy}\,dy \qquad bb' = \frac{dx'}{dy}\,dy,$$

whence may be derived—

$$oa = dx\sqrt{\left(\frac{dx'}{dx}\right)^2 + \left(\frac{dy'}{dx}\right)^2} = dx\left(1 + \frac{d\xi}{dx}\right) \qquad (1)$$

$$ob = dy \sqrt{\left(\frac{dy'}{dy}\right)^2 + \left(\frac{dx'}{dy}\right)^2} = dy\left(1 + \frac{d\eta}{dy}\right) \tag{2}$$

$$\cot\theta = \frac{\frac{dy}{dx}\frac{dy'}{dy} + \frac{dx'}{dx}\frac{dx'}{dy}}{\frac{dx'}{dx}\frac{dy'}{dy} - \frac{dy'}{dx}\frac{dx'}{dy}} = \frac{d\eta}{dx} + \frac{d\xi}{dy}, \tag{3}$$

and writing—

$$a = \frac{d\xi}{dx}, \quad \beta = \frac{d\eta}{dy}, \quad w = \frac{d\eta}{dx} + \frac{d\xi}{dy},$$

we may remark that a and β are positive for dilatations, and negative for compressions; and that ω is positive for values of θ less than 90°, and negative for values greater.

Let D represent the diagonal of the original rectangle, and d the diagonal oc of the parallelogram; then, since—

$$D^2 = dx^2 + dy^2$$

we find—

$$\begin{aligned} d^2 &= \overline{oa}^2 + \overline{ob}^2 + 2\overline{oa} \times \overline{ob} \times \cos\theta \\ &= D^2 + 2\ \{a dx^2 + \beta dy^2 + w dx dy\} \end{aligned}$$

or, if the diagonal, D, of the rectangle make angles λ, μ with OX and OY, we find—

$$\frac{d^2}{D^2} = 1 + 2\ (a \cos^2\lambda + \beta\cos^2\mu + w\cos\lambda\cos\mu),$$

and, extracting the square root—

$$\frac{d}{D} = 1 + (a \cos^2\lambda + \beta\cos^2\mu + w\cos\lambda\cos\mu) \tag{4}$$

i. e.—

$$\frac{d}{D} = 1 + \varepsilon,$$

where ε denotes coefficient of linear dilatation of the diagonal of the rectangle.

If this coefficient be represented by the radius vector of a curve, so that—

$$\varepsilon = \frac{1}{r^2},$$

it is easy to see that this curve will be a central curve of the second order, whose equation will be—

$$1 = ax^2 + \beta y^2 + wxy. \tag{5}$$

The axes of this ellipse are the directions of maximum and minimum dilatation or compression, and point out the directions in which the bed tends to break.

1st. If, for example, the disturbing forces were such as to compress or dilate the bed parallel or perpendicular to OX, and to produce no other effect, then the angle θ would continue equal to 90°, and $w = \cot\theta = 0$, and the equation of the ellipse would be—

$$ax^2 + \beta y^2 = 1 \tag{6}$$

whose axes, OX and OY, are the directions in which these beds would tend to break. This condition would be fulfilled by points situated at a great distance from the porphyry dyke.

2nd. If the distortion produced by the trap dyke were such as to produce no relative motion in the direction OY (which may be supposed, as the pressure of the dyke is lateral in the direction OX), then—

$$\beta = \frac{d\eta}{dy} = 0,$$

and the equation (5) becomes—

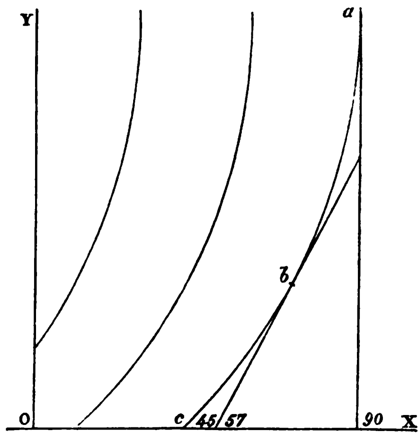
$$ax^2 + wxy = 1, \tag{7}$$

which is the equation of an hyperbola, whose asymptotes are the line OY and another line, making with OY an angle whose tangent is $-\frac{w}{a}$. The magnitude of this angle will depend on the relative magnitudes of w and a; and at points situated very near the line OX (if we suppose the beds not to slide on the line OX) we shall have $a = 0$; and since, from the nature of the forces acting, the angle θ is acute, w will be positive, and a will be negative, since it corresponds to a compression of the beds. Therefore, at points near the line OX, or porphyry dyke, the angle made by the asymptotes will be 90°, and the line of fracture will make with OX an angle of 45°.

3rd. In general, the direction of the axes, or lines of fracture at any part of the bed, may be thus found:—The angle ϕ, made by the axis of the conic (5) with OX, is known to be given by the equation—

$$\tan 2\phi = \frac{w}{a - \beta}. \tag{8}$$

The intrusion of the trap dyke produces a lateral pressure in the direction OX, the line OX itself being fixed, or nearly so; and consequently the movement of the particles composing the bed is greater as the distance from OX increases, and is towards the right hand; hence the angle θ is acute, and w positive; a is negative, because it is a coefficient of linear dilatation, corresponding to a compression of the bed; and β is smaller than a; hence $\tan 2\phi$ is always negative, and therefore ϕ lies between 45° and 90°; approaching the former limit in the parts of the bed near the line OX, and the latter limit in the parts of the bed remote from OX.



The effect of the lateral pressure of the trap dykes, acting on the beds placed as

we have supposed, so as to push them obliquely against the porphyry dyke, will therefore be to produce a series of curved fractures, such as *abc*, the direction of which makes with the porphyry dyke OX, at the point of intersection *c*, an angle of 45°; at the point *a*, situated very far from the porphyry dyke, an angle of 90°; and at intermediate points, as *b*, angles lying between these extreme limits.

December 14th, 1853.—"On the Structure of the North-Eastern Part of the County of Wicklow." By J. Beete Jukes and Andrew Wyley, Esqrs.

In revising the six-inch map of the Geological Survey, previously to laying down the results of the work upon the new inch-sheet map shortly to be published, we were led to take a rather different view of the main features of the structure of the north-eastern part of the county of Wicklow from that which has previously obtained.

In stating this view we wish emphatically to remark, that we impute no deficiencies to any of those who had previously examined the country, since without the benefit of their previous labours it is possible we might not have arrived at our present results. The country is one of almost unexampled difficulty: difficulty arising in part from the very complicated and often almost inexplicable structure of the rocks, and in part from the discontinuity of the sections, and the widely separated position of the rock exposures, the intermediate spaces between them being buried under thick and broad accumulations of drift.

We have, however, now re-examined—in many instances for the fifth and sixth time—every exposed portion of rock within the district we intend to describe, and we offer the following results with the utmost confidence in their general correctness, while of the many doubtful localities we believe that we have seen and know all that can, under present circumstances, be ascertained.

The formations to be described are those commonly known as—

I. The Cambrian.
II. The Lower Silurian.

We use these terms as those which have been commonly in use during the last few years, without reference to their abstract propriety, and without expressing any opinion on the controversy which has arisen as to that nomenclature.

I. *The Cambrian Rocks.*—These consist principally of *green and purple grits and green and purple slates*, the beds of each being almost always thick and massive, and those of the grits being frequently very irregular. The structure and appearance of the grits vary greatly. They are of all shades of colour, from bright red to a dull, dark, purplish gray, and from an apple green to a pale gray; the green colour, however, greatly predominating over the others. Their texture, likewise, varies from an exceedingly compact, close-grained sandstone to a coarse granular grit. Sometimes the latter is made up of crystals, so slightly rounded that the rock may be easily mistaken, and sometimes has been so, for an igneous rock. The crystals are of quartz alone, or of quartz in an earthy, feldspathic-looking matrix, and the rock assumes the appearance of a greenstone or a porphyry. Flakes of white mica, however, are commonly disseminated here and there through all the grits; and these, together with the rounded angles of the crystals, and the bedded appearance of the rocks must be sufficient to guard the observer against error. In no part of the formation have we ever observed anything that could be called a conglomerate or a breccia.*

Some of the more purely siliceous grits often seem to be on the point of passing into quartz rock, and are, indeed, scarcely to be distinguished from it, except, perhaps, by their colour, by a slight difference in hardness, and by the absence of that utterly jointed structure so characteristic of quartz rock.

All the grits are, however, very hard, and some of them "tough" also, so that their fracture is excessively difficult.

The slates vary in colour as much as the grits, and assume exactly similar hues, except that in addition to the reds, greens, and grays, they sometimes put on an olive-brown colour, varying between greenish and yellowish. The olive-brown colour is probably a superinduced one. It is usually confined to those slates and grits lying close to the quartz rock, and seems to be due either to the action, whatever it was, that changed the sandstone into quartz rock, or perhaps to subsequent infiltration; the beds lying near the

* Near Howth Harbour are small patches of a conglomerate or breccia plastered against the cliff in Poulscadden Bay; but we have considerable doubts as to the age of these patches, and believe they are not belonging to the Cambrian rocks, though made up of their *debris*, and are rather inclined to refer them to the age of the old red sandstone.

hard and unyielding quartz having been more broken up, and thus rendered more permeable to atmospheric moisture than those at a distance. The slates, also, assume every variety of texture, from a mere earthy "cleaved sandstone" or "flagstone" to a very fine-grained, smooth roofing slate. Many of the more irregular of the slates might, perhaps, with more propriety be called "shale," or "schist." They often look chloritic, and have a soapy touch.

Alternations of red and green, and other colours, often occur in the slates; and these alternate bands most commonly, but *not always*, mark the stratification. It is important to recollect that the changes of colour do not always coincide with the planes of stratification (as proved by beds of grit and alternations of texture), and that they sometimes even have no relation at all to each other, but cross at right angles, or in any other direction.

Throughout the Cambrian district of Wicklow there is a remarkable absence of any igneous rock. The only two localities we know where such rocks appear is, one at Greystones, where a dyke of a highly hornblendic crystalline greenstone cuts through the low cliff of Cambrian grits; and the other of a very crystalline epidotic greenstone, a little south of Roundwood.

In addition to the ordinary grits and the slates, the Cambrian rocks of Wicklow are characterized by an abundance of quartz rock. This is ordinarily of a yellowish-brown or yellowish-white colour, varying in texture from compact to granular; the grains, as in all quartz rocks, looking as if partially run together at the edges. The quartz rocks have every possible gradation into the grits.

The ways in which these several kinds of rock are combined and interstratified one with the other are so very various that it is very difficult to throw them into groups, or to assign to them any regular order of sequence that shall be true for the whole district.

Their total thickness seems to be enormous, since that shown, to all appearance, and without any reason for doubt, in one or two several localities exceeds many thousand feet; and if these are really different parts of the same series, the total thickness must reach at least twenty or thirty thousand feet.

From the difficult nature of the country it is with much doubt and hesitation that we venture to suggest, rather than to declare, the following two groups, beginning with the lowest:—

1. The Ashford and Devil's Glen group, characterized by the

relative abundance of massive grits, and the more frequent occurrence of red slates. It has but little quartz rock associated with it.

2. The Bray Head and Sugarloaf group, in which the slates are relatively more abundant than the grits, the green colour much more predominant than the red, and the quartz rocks assume their most abundant and important features.

We should likewise be inclined to consider the obscure fossil zoophyte, named by Professor Forbes "Oldhamia," after the former distinguished Local Director of the Survey, Professor Oldham, as characteristic of this group.

II. *The Silurian Rocks.*—We wish, in describing this formation, to confine our observations mainly to its base, or to the lowest beds in the county of Wicklow. Whenever these can be certainly ascertained, they have been invariably found to consist of what would be ordinarily termed "black slate." Very often this is really black, and sometimes carbonaceous looking, so as when decomposed to resemble coal shale. More frequently, however, the slates are dark bluish gray, or dark iron gray, looking really black only when they are wet. They are always very fissile, and commonly very brittle and rotten, breaking immediately into small thin plates, so that except from a quarry it is difficult to get and preserve a slab of them larger than the hand. They are almost always interstratified with thin, iron-gray, siliceous grits, forming little beds of an inch or two in thickness. These grits sometimes occur as lines of lenticular-shaped nodules, instead of continuous beds. Beds of trappean feldspathic ash, generally of a pale greenish-gray colour, are sometimes associated with the black slates, even to their lowest beds. Higher up in the black slates there often occur bands of slates similar in mineral character, but coloured brown or yellowish, or sometimes assuming an olive colour, and they then become very similar to the olive-coloured slates in the upper part of the Cambrian rocks; the colour being probably in each case due to some subsequent action of decomposition.

Above these again, but very much higher up in the series, occur bands of red or purple slate, and even of red and green slate, which can scarcely be distinguished in hard specimens from some of those of the Cambrian rocks. There are, however, slight lithological distinctions; and their immediate association with the black slates obviates the possibility of any important mistake being made be-

tween the two formations. The most striking distinction between them, and one which appears invariable, is, that the Cambrian rocks never contain any *black slate*, and the Silurian never have any thick, massive, green and purple grits.

In describing the actual position of the component portions of the two formations, and their relations to each other, it will be necessary to commence in the neighbourhood of Rathdrum, and proceed thence northwards to Bray and Killiney.

A few miles west of Rathdrum is the valley of Glenmalure, through which flows the river Avonmore. On the flanks of Glenmalure we see resting on, or abutting against, the granite a dark gray mica schist, which, as we recede from the granite, rapidly passes, apparently by insensible gradations, into the ordinary black, blue, or dark gray slate of the Silurian formation. This, towards the east, becomes variously associated with many igneous rocks, but it preserves, as to its aqueous portion, the same lithological type from the granite to the sea. The dark slates are frequently interstratified with grits, which in some places thicken out to two or three feet, and with thin bands of slates of paler colour than usual; but it would not be possible on this line of latitude to draw any good boundary line in the series, so as to say there was any essential difference of character in the rocks above and below it. It is true they put on an altered appearance when they approach the granite hills, but so they do in the very heart of the formation a little south of Rathdrum, at Ballinaclash, where a small boss of granite protrudes through them; and in each case they suffer a similar kind of alteration, namely, the development of mica.

If now we travel north from Glenmalure along the foot of the granite hills, and examine each valley and brook as we proceed, we shall always find exactly the same dark gray micaceous schist resting on the granite, and passing in a very short distance to the eastward into black or blue clay slate.

This is true for the whole range of the granite hills from Glenmalure to Killiney; it is also true southward of Glenmalure as far as the granite extends. In proceeding north, however, we should find that when we arrived at the neighbourhood of Annamoe and Roundwood we should no longer meet with these dark-coloured slates occupying the whole ground eastward from the granite to the sea; but that, after passing a certain straight line running nearly

N. N. E., parallel for the most part to the granite, and at a distance of about two or three miles from it, we should find ourselves among the Cambrian rocks, consisting of massive grits and slates, with much quartz rock. If we set to work to discover how these Cambrian rocks came in, we should have great difficulty in arriving at any conclusion by examining the line of country just mentioned, from the defect of any good natural sections; but a very careful examination of the southern border of the Cambrian rocks between Annamoe and Ashford would enable us to see a distinct and very wide unconformability between the two formations, and that the black Silurian slates were in reality resting on the upturned edges of the Cambrian rocks.

In the neighbourhood of Rathdrum, the strike of the Silurian rocks—as shown by detached dips, and by the lines of their associated grits and contemporaneous trap rocks—is about N. E. by N.; the dip being almost invariably at a very high angle, and most commonly towards the south-east. In the Cambrian rocks, however, west of Ashford, about the Devil's Glen, and in all the neighbouring country, the strike is almost invariably east and west, and the dip to the northward, at angles varying from 60° to nearly 90°. The common boundary of the two formations is at one part remarkably undulating, with deep bays and projecting promontories; the black slates of the Silurian formation occupying the ridges of the hills and higher grounds, and the red and green grits of the Cambrian being seen only in the valleys and flats.

In the ridge of Ballycullen, which runs south of the Devil's Glen, about two miles west of Ashford Bridge, we have a long island or promontory of black slate (we cannot say exactly which), running about N. E. by N., nearly three miles long, and not more than half a mile in width. There are many small quarries and cuttings in this black slate, but it is difficult to make out its stratification except at the cutting of the road from Ashford to Annamoe. The beds here are for the most part vertical; but in one larger exposure than usual, they are seen, by the occurrence of grit bands, to be violently contorted and crumpled up, the flexures being so excessively sharp and sudden as easily to be overlooked unless very well exposed.

In the valley on either side of this ridge, and for a certain distance up the slope of its eastern side, are seen many knobs and hum-

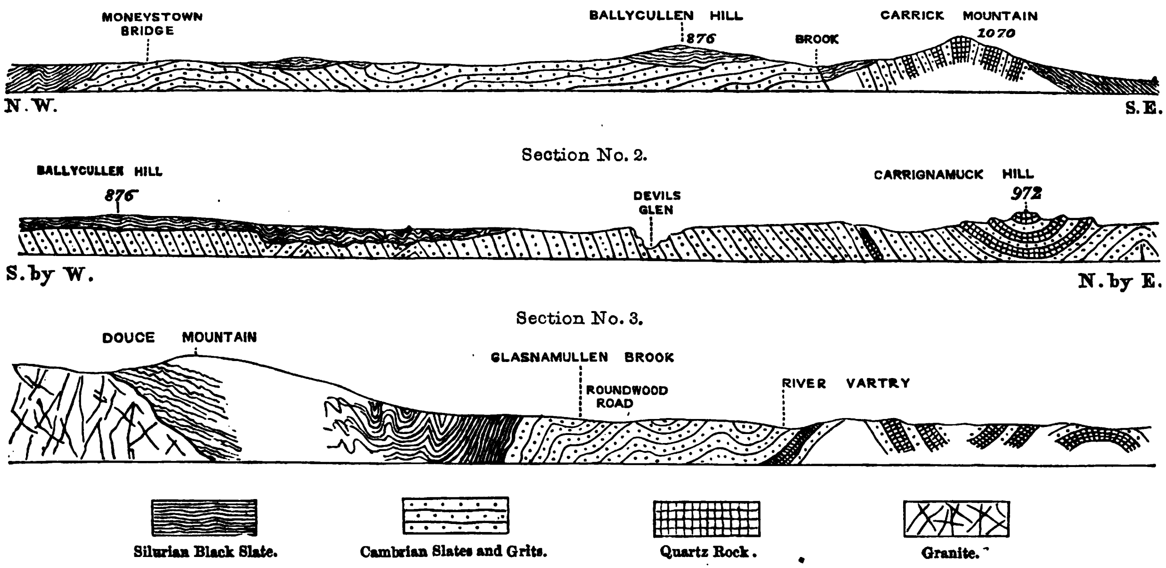
mocks of massive green and purple sandstone, with interstratified beds of red and green slate, every one of which have a strike varying from E. N. E. and W. S. W. to W. N. W. and E. S. E., or striking directly *at* the boundary of the black slates. The dip (see Sections Nos. 1 and 2) is nearly, if not quite, invariably to the northward, at an angle never less than 60°, and the rocks have all the appearance of striking through the base of the hill, and having their edges covered up by the contorted and crumpled beds of the black slate on the upper part of the ridge.

West of the Ballycullen ridge is a flat, boggy piece of ground, about a mile in width, exposing rough knobs of Cambrian rock dipping at high angles to the north; and west of that again rises another high ground called Moneystown Hill, on the flank of which the black slate again sets in at about the same level above the sea as in Ballycullen ridge, namely, about 700 feet. At one point here, by the road at the junction of the townlands of Moneystown (North and South) and Kilmullen, the unconformity is even locally apparent, as the black slates may be seen on one side of the road dipping at an angle of about 10° to the westward, while on the other side the green and purple grits dip S. E. at 60°.

Passing over the northern end of Moneystown Hill, we again come upon a flat, where bosses of the Cambrian rocks show themselves; this flat being closed to the south-west by the high land of Trooperstown Hill, whence a ridge runs northwards to Castlekevin; the whole of the ground above a certain level being occupied by black slate as before.

At Castlekevin we are at the southern extremity of the straight, or nearly straight, line of boundary before described, running thence by Roundwood to Killiney.

In following along this line of boundary we have only one tolerable section of the two formations exposed,—that, namely, in the bed of a small brook on the flank of Douce Mountain, at a place called Glasnamullen (see Section 3). We have here, below the Enniskerry and Roundwood road, the Cambrian rocks in their most characteristic form, a good deal contorted, but dipping on the whole to the westward at angles varying from 30° to 80°. Above the road they dip still principally to the westward, so far as can be seen, but with occasional rolls to the southward, until about a quarter of a mile above the road the black slates come in quite suddenly, and in a po-



Sections to illustrate the Paper on the Structure of the North-Eastern Part of the County of Wicklow.
By Messrs. Jukes and Wyley.

sition closely approaching to the vertical. The upper sides of their beds, however, appear to be to the westward; and it is believed that the westerly dip is continued for some distance till a considerable thickness of black slate is accumulated before the beds rise again on to the flanks of the granite. For a space of about a third of a mile from the granite they dip easterly at angles of 20° or 30°, and have assumed the ordinary form of mica slate. Their lowest beds down in the brook are interstratified with some peculiar varieties of feldspathic ash or similar rocks.

In the valley of the Cookstown river, near Enniskerry, the black slates of the Silurian formation are suddenly deflected widely from their previous boundary, running from Enniskerry down to a little beyond the lower bridge of the Dargle glen, about a mile from Bray, just below which bridge, in the grounds of a cottage residence called Riversdale, rocks of the Cambrian formation again make their appearance. At the lower end of the Dargle glen, ash beds, exactly similar to those before mentioned, may be seen irregularly interstratified with the black slate. This projecting tongue of black slate is believed to be brought in by a large fault running nearly east and west, and having a downthrow to the north. Cambrian rocks may be seen at St. Kevin's Well again, to the north of this tongue, from which point the boundary of the Silurian rock is believed to resume its north-easterly course to the shore south of Shanganah, but its actual place cannot be determined, as the whole rocks are buried in drift.

In attempting to sketch the structure of the ground formed by the Cambrian rocks that lie between the boundary thus roughly described and the sea, it will be necessary to return to the vicinity of Ashford.

The red slates of Glenmore Castle, and the flanks of the Ballycullen ridge, dip to the northward, and pass under the massive grits and slates through which the ravine of the Devil's Glen has been excavated. These likewise dip almost invariably to the northward, except about the Waterfall, where they are sharply undulated in various directions. Taking the Devil's Glen as the centre, over all the country from Ballyduff Bridge on the west, through Ballycurry Hill and Rathmore to Castlegrange on the east, a distance of more than four miles; and from Ballycullen on the south to Dunran Hill on the north, a similar distance of four miles,—the prevailing dip is

steadily to the northward, often at very high angles, and sometimes absolutely vertical. There are, it is true, many small local flexures to the east or west of north, and some places where a southerly dip is possible, although it is not certain; it is true, also, that where the beds are vertical their upper surfaces may in some places be to the southward as probably as to the northward; still the main fact remains of there being a vast thickness of rock here striking east and west, and dipping mainly to the north. The same fact becomes evident on tracing the run of the quartz rocks. At Rathmore, for instance, there are two or three narrow, interrupted beds of quartz rock, running nearly east and west for about two miles, all the dips near them being to the northward. These beds end suddenly to the eastward in a very remarkable way, as exactly in the strike of them, across one narrow field and a road, are seen beds of slate and gritstone, with the same strike and dip, but utterly devoid of quartz rock. They end to the westward in an equally abrupt manner near the village of Killiskey, but to the north-west of that, quartz rock again sets in; and on the side and summit of the Hill of Carrignamuck huge ridges and bosses of quartz rock, with slates peeping out here and there between them, come in in the most perplexing way, running in all sorts of directions, stopping out suddenly and then recurring again, so that we found it a hopeless task, after some days' labour, to disentangle the confusion of their minute details. After passing over this hill, however, quartz rock again appeared in the marshy flat beyond, interstratified with slates and sandstones, the whole dipping very steadily to the north at 60°. These quartz rocks, however, again end suddenly in the townland of Knockfadda, and are nowhere seen to the westward, where the rocks for some distance seem to have suddenly altered their strike, dipping at angles of 50° or 60° to S. E., E., and N. E.

It is remarkable that these two breaks in the continuity of the quartz rocks occur about in the direction of the projecting promontories of black slate of Ballycullen and Moneystown, if the general bearing of those features were prolonged. This prolongation also would have a bearing about N. E. by N., parallel to the general strike of the Silurian formation farther south. It is probable, therefore, that the interruptions and dislocations of the quartz rocks may be in part connected with the occurrence of great lines of intense disturbance and dislocation affecting the Cambrian rocks in a

direction across and nearly at right angles to the strike that had been formerly communicated to them by elevatory forces acting before the deposition of the Silurian beds.

It is clear that the Cambrian rocks must have been elevated, and must have suffered from denudation very largely, before the deposition of the Silurian rocks. If any contortions were produced in them at that very ancient period by forces acting in one direction, and if at a long subsequent period new forces of disturbance were brought into play, producing contortions and dislocations having no connexion with or relation to the former ones, it may well happen that it may now be almost utterly impossible for us to unravel the perplexity and confusion thus produced, even if we had every portion of rock bared and washed clean for our inspection. When we recollect that of such a Chinese puzzle we have only a fragment here and there exhibited to us, it may be a good warning to us to hesitate before we assert any decided conclusions as to minute points of detail.

Taking, however, the district now described as our base line, and assuming the prevailing inclination of the beds to the north to be real as well as apparent, the rest of the Cambrian district may be briefly described as follows:—

In the high grounds of Ballinahinch, Tithewer, and Drumbawn, west of Newtownmountkennedy, there are a few occasional lines and knobs of quartz rocks striking about N. E. and S. W.; the dip of the rocks varies from N. W. to S. E., usually at angles exceeding 40°; and we believe that there is a rather larger undulation of the beds here, producing one or two synclinal and anticlinal curves, and that a synclinal in Ballinahinch Hill brings up the beds that had previously dipped north, making them rise in that direction nearly as far as the river of Altidore, where the dip becomes again N.W. One or two sharp flexures, on a smaller scale, then appear to take place; the beds finally plunging to the northward, under the two Sugarloafs and Bray Head.

As this northern district is an interesting one, and has already been the subject of discussion before the Society, we will here venture to give our present views of its structure in a little more detail.

The ridge of quartz rock which forms Walker's Rock is traceable nearly north and south for about three miles just east of

Powerscourt Deerpark, dipping, as far as can be ascertained, to the eastward, at an angle of 70°. East of this the grits and slates suffer some local flexures, but finally plunge east under the Great Sugarloaf. This hill is one great bed of quartz rock, the base of which we believe to be marked by the ledge that occurs on the west side of the mountain, and its upper surface by a patch of unaltered gritstone with slate, which minute search discloses near a gully on its eastern slope. To the north the beds seem to be all cut off by a fault, which we believe to run down the glen from near Coolakay to Kilmacanoge, and thence through Kilruddery Deerpark to Windgate.

On the south side of the Sugarloaf the beds appear to curve round to the east and dip north, striking easterly by Kilmurry North, and then curving round and striking north through Kilruddery Deerpark. Here we can see them on the higher ground dipping west under the main quartz rock of the Little Sugarloaf.

This position of the beds of the Sugarloaf Hills supposes them to form a sort of rude basin, the quartz rock of each Sugarloaf being the same mass, dipping east in the Great one, and west in the Little one, with a thin patch of slate lying concealed under the drift in the hollow between them. This great bed of quartz being cut off by the fault before mentioned (which is an upthrow to the north), and the ground north of the fault being lower, forms a smaller tongue-shaped mass running as far as Hollybrook, with the lower beds rising from under it on both sides; and we believe it to be the same bed that forms the massive quartz rock of the summit of the hill of Carrigoona Commons, and possibly also the same with the massive quartz on the northern summit of Bray Head.

The smaller lines and ridges and spots of quartz rock we believe to be parts of beds that all lie underneath this large one, and show themselves here and there as they are brought up and exposed by the various flexures and contortions of the strata.

Bray Head, although at first sight very simple in its structure, and consisting of a huge mass of slates and grits, with interstratified quartz rock, all dipping to the north, yet presents many difficulties for explanation when minutely examined. Of the eight beds of quartz rock which strike regularly over the top of the hill in parallel lines, running N. E. and S. W., two only come down to the sections on the coast and in the cuttings of the railway, where the dip

and strike seem remarkably regular and persistent, being almost invariably to the N. N. W., at 50° or 60°. We have been led to doubt whether the appearances here are not deceptive, and whether there may not be a great flexure (or perhaps even more than one), the beds being bent back upon themselves, so as all now to appear to be dipping to the northward. If this is not the case, it appears possible that some of the beds may be cut off and concealed by the action of a fault running obliquely along the eastern slope of the hill; and some such fracture appears probable from the examination of the eastern end of the southern line of quartz rock. In either case, we believe that the large mass of quartz rock on the northern slope of the hill, and which we are inclined to identify with that of the Sugarloaf, merely rests on that slope of the hill, and is cut off to the north by the east and west fault, mentioned before as running by Enniskerry, and bringing in the tongue of black slate. This fault must be a downcast to the north; and this quartz-rock bed will then be that which is shown here and there about the town of Bray, and appears to dip to the eastward, and strike the sea-coast somewhere north-east of the town, being buried in that direction under the drift.

We have now to describe briefly three outlying districts of Cambrian rock, occurring within the limits of the space we have intended to discuss.

The first of these is in Carrickgollogan, or Shankhill. The quartz rocks and lighter-coloured slates of this hill we believe to belong to the Cambrian formation; they are surrounded on one side by mica schist, and on the other by black slate, both of which we believe to be Silurian.

The second is a district south of Roundwood, where a small tract of red and green slates and grits, with one boss of a kind of greenstone, is likewise surrounded by black slate. Some of the altered Cambrian rocks of this locality assume some of the external characters of serpentine.

The third district is much larger and more important, being the range of Carrick Mountain, which, with the two minor ridges of Cronroe and Ballinastraw, runs nearly N. E. and S. W. for six miles, beginning at Ballinalea, a little south of Ashford Bridge. The quartz rocks of this range are very bold and massive, forming often great crags and ridges of bare rock rising from 20 to 60 and 80 feet

above the adjoining ground. Slates and grits of red, green, and olive-brown colours may be indistinctly observed here and there between them, and wrapping round their ends, and in a few places enough of these are exposed to give us an observation for the dip of the rocks. This was generally found to be at a very high angle, either to the N. W. or S. E., more often the latter; the angle usually greater than 60°, and oftener approaching the perpendicular.

Black slate may be observed in the cuttings of the roads between this ridge and the rest of the Cambrian district, but never in sufficiently large quantity to afford any clue to its real inclination, or relation to the rocks below. The N. W. boundary of this black slate, however, runs in such a very straight line for several miles, and it forms so marked a feature in the shape of the ground, that we were induced to consider it as a line of fault. This conclusion was strengthened by the fact that the Cambrian rocks of Carrick Mountain do not at all resemble those of the immediately adjacent country, but much more nearly those of the neighbourhood of Bray Head and Kilmacanoge; in addition to which, Oldhamias have been found in those three places, and in no other locality that we are aware of. If, however, the rocks of Carrick be really the upper part of the Cambrian formation, and those of Aghowle and Ballycullen be the lower, the strike of the first being N. E. and S. W., and the strike of the latter E. and W., in each case over a district of some miles in extent, and running side by side with each other, it is clear there must be a dislocation of very great magnitude between the two.

As the two principal results of this paper, we wish to call attention—

First, to the unconformability between the Lower Silurian and Cambrian rocks.

Secondly, to the position of the stratified rocks, taken *en masse*, with regard to the granite.

1. In north Wales we have the lower Silurian rocks, principally dark gray and black slates, with many contemporaneous and intrusive feldspathic and hornblendic traps, resting apparently quite conformably on a great series of red and green grits and red and green slates, to which series the term Cambrian has been restricted by the Survey. These Cambrian rocks are, in North Wales, quite unfossiliferous so far as is known, but they agree in all their mine-

ral and lithological characters, except in the occurrence of quartz rocks, precisely with what we have called Cambrian in Wicklow. These Wicklow Cambrians are likewise unfossiliferous, with the exception of the remarkable fossil zoophyte, Oldhamia.

In North Wales it is rather difficult to draw any good physical boundary between the two formations. The unconformity between them in Wicklow, however, establishes a good physical break and interval between them in that locality. That it is a local unconformability appears probable, because when we go into Wexford it possibly disappears, though even there, there are certain evidences of unconformability in particular places, and presumptive evidence in favour of it when the rocks are viewed on the large scale, inasmuch as, though striking in the same direction, and dipping at the same angle, the rocks which in one place lie immediately under the black slate appear different from those which underlie it at another.

You will see that we are here on the traces of questions which must have a direct bearing on the general classification of the lower palæozoic rocks.

2. The position of the stratified rocks with regard to the granite is very interesting, as tending to modify the ideas with regard to the physical action of this rock, which, if not now prevailing, have only just ceased to be universally entertained. It was always thought that the eruption and elevation of a great range of granite invariably brought up upon its shoulders the lowest formation of the neighbourhood, and flung off the upper ones to a greater distance from its flanks, in proportion to their newness.* In North Wicklow, however, we see, according to our present results, that the granite has in no instance the lowest formation, namely, the Cambrian, in contact with it, in no instance brings any portion of it up upon its flanks; but on the contrary, that the Cambrian rocks either dip towards the granite when they approach within a couple

* I may remark here, that I had long ago been suspicious of the fallacy of this notion, and been inclined to attribute the elevation of rocks generally to a great widely-acting force, most probably the action of great heat, of which the production of igneous rocks was one of the local symptoms; but to look on the actual outburst of igneous rock as tending to produce depression rather than elevation in its immediate neighbourhood, except so far as the mere puckering and crumpling of the beds directly in contact with them are concerned.—(*Note by J. B. Jukes.*)

of miles of it, or pay no regard to it at all; and that the Silurian rocks which rest upon the granite have their beds tilted up by it only when very near it, and then at comparatively low angles, while a mile or two off they are almost invariably vertical, much contorted, but seem to have a general tendency to plunge headlong in the direction of the granite. It seems as if the elevation of the granite and its outburst had left a great hollow or cavity, as it were, running parallel to its present general direction, and a little distance removed from it, and that the rocks had sunk bodily into this cavity, suffering greatly from lateral pressure, doubtless, during the process, while rocks still farther removed had remained wholly or comparatively unaffected.

Although it is beyond the limits of this paper, we will just add, that the position of the rocks on the Kildare side of the granite confirms these conclusions. The lowest rocks are farthest removed from the granite; and, notwithstanding many sharp flexures which are seen here and there, the general dip of the whole is towards the granite, except immediately on the flanks of that rock where the beds are bent up against it.

Postscript.—Since the above was written we were induced to examine the little island of Ireland's Eye. In that small space we find a very good example of the two formations, Cambrian and Silurian, in positions which almost necessarily involve their unconformability, though that is nowhere actually apparent in any one spot. Along the north of the island stretches a bold ridge of quartz rock, which on the western side is a good deal interrupted and intertangled with slates and unaltered grits. South of this, on the western shore, we have a considerable space occupied by red and green slates and grits, greatly contorted, but on the whole striking east and west, and dipping apparently to the south. In this direction there come in, about the middle of the island, beds of black slate with thin grits, bands, and nodules. These are likewise contorted, but on the whole dip nearly south for a considerable distance, till on approaching the south end of the island they rise suddenly in that direction, at a very high angle; and there comes out from under them a mass of green slate, with green grits and some quartz rock. So far there is no direct evidence of unconformability; but on the east side of the island the black slates are continued much further

north than their line of boundary on the west side, and are seen well exposed in the cliffs forming all the higher ground, and continuing till they rest against the quartz rock, which forms the northern ridge of the island.

It thus appears that the red and green slates, and grits, which on the west side of the island come in above the quartz rock, and are seen striking across the low beach in bristling rocks for several hundred yards south of the quartz rock, are completely overlapped and concealed by the black slates on the east side of the island; and nothing is allowed to appear through these except the harder and loftier ridge of the quartz rock.

The black slates here appear generally to be dipping to the south here, away from the quartz rock; but they are frequently contorted, and we have long learned to attach very small importance to the appearance of *dip* in such yielding beds as the black slate when they have at all been affected by disturbing forces. The relations of such beds to the surrounding rocks can only be with certainty ascertained when large districts have been carefully examined, and the general outlines and behaviour of the rocks completely determined.

Mr. J. W. Salter informs us that palæontologically the Silurian rocks of Wicklow and Wexford represent the "Bala beds" of North Wales, and that there is among them no palæontological representation of the still lower group of the "Lingula flags." Simultaneously, then, with the unconformability between the two systems of rocks, there is a gap in the sequence of groups which exist elsewhere. The elevation and denudation of the Cambrian rocks, then, which is the proximate cause of the unconformity, may have occurred in the interval belonging to the "Lingula flag" period.

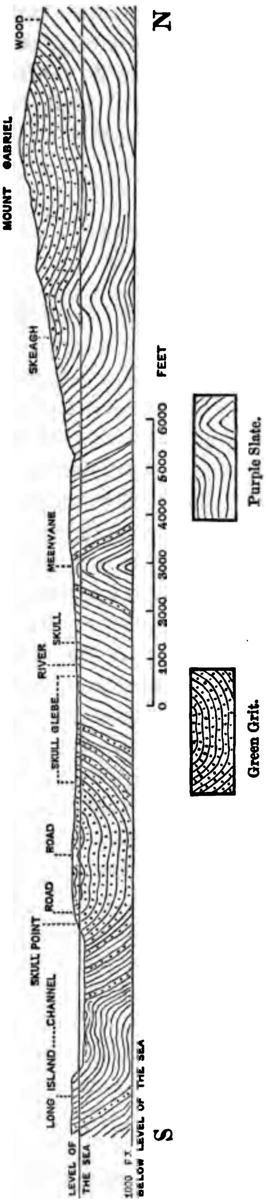
January 11th, 1854.—Thomas Dawson Triphook, Esq., read a Paper "On the Geology of the Neighbourhood of Skull, in the County of Cork, accompanied by a Geological Section from the eastern end of Long Island to western boundary of Mount Gabriel Wood."

Long Island is one of those numerous small islands on the south-west coast of Cork, forming a natural breakwater to Skull Harbour,

and on the western side is about nine miles from Cape Clear and the Fastnet Rock. Mount Gabriel is about 1329 feet high, the highest hill in this part of the country: it is a part of one of the long peninsulas running towards the south-west, and forms one side of Dunmanus Bay, on the other side of which, separated by a similar peninsula, is Bantry Bay.

There is a large gap or ravine in Mount Gabriel, at about half the height, through which a new road has been carried, and there appear on its side and bottom scratches or striæ, similar to those mentioned by Mr. Lyell as occasioned by the passage of icebergs, and they seem worth the attention of a geologist, as being the only passage through which, on the emergence of land, such bodies could have passed for a considerable distance. Not far from the top of the hill, and close to the line of section, is a small lake of about six or eight feet deep, surrounded by cliffs, where good observations of dip can be had.

The rock represented in section consists of two distinct varieties of sandstone; the one commonly called purple slate, and the other green grit, with their corresponding shales. Though the rock is abundant, it is difficult to obtain quarries for building materials: first, there are so few jointed beds; secondly, the stones are so laminated from cleavage that few, excepting large masses, can be got



Section to illustrate Mr. Triphook's Paper on the Neighbourhood of Skull.

out above six or eight inches thick. The green grit can be chiselled or cut for masonry, but for this purpose is not easily obtained, though this rock is much better jointed than the purple grit. It has been analyzed in the Laboratory of Trinity College, Dublin, and found to consist of—

Silex, ...	94
Oxide of iron and alumina, ...	4
Alkali, ...	2
Lime, ...	Trace.

The cleavage is generally a few degrees from the vertical; and it is exceedingly difficult in some places, from the compactness of the beds on each other, to distinguish the true dip of the beds, especially when the latter are nearly vertical; but when flat, the cleavage seldom or ever runs through two adjoining beds in the same direction: hence this may be used as a means of distinguishing two beds. The shales are also of importance in this respect in these rocks, together with hard nodules, which stand out from the face of the rock after exposure to the weather.

The country appears to have undergone very considerable denudation; it is consequently rare to discover any anticlinal axis which has not the top of the upper beds completely cut away, and the occurrence of such an axis is only recognised in some places by the sudden reversion of the dip.

The principal minerals are quartz, chlorite, micaceous iron, malachite, copper pyrites, iron pyrites, sulphate of barytes, with bog iron and wad. Of these the quartz veins with chlorite are very abundant. Generally associated with chlorite is the micaceous iron; and in most of the quartz veins, when these occur together, they are generally looked on as taking the place of copper ore, which, though of excellent quality in this country, is deficient in quantity and greatly scattered.

No fossils, that I am aware of, have been discovered in this district; but, as regards position, these rocks lie under mountain limestone and magnesian limestone at Cork, to which place they continue; but as they go eastward the purple slate becomes of a red colour, lying, as in section, under the green grits, over which, and when they are wanting on the red slate, the limestone is imposed; also, as they approach Cork, they assume more the appear-

ance, especially in the green grits, of a conglomerate of hard nodules and cementing matter, as though the heavier particles were first deposited in shallower water, while the finer were carried out to the deeper towards Cape Clear.

There is no limestone within thirty miles of the line of section; consequently the lime is imported, and sea-sand is used for agricultural purposes in its place.

The contortion (shown on the section) under water in Long Island channel is seen at the western end of the island, and in another to the westward of it; so that the line passing through them parallel to the strike on the island and main land would place the same contortion, if carried on, as is probable, as shown in the section, and by the arrows and colour on the map.

The strike of the rocks in this country is very uniform, generally from E. and W. to E. 10° N.

The heights are taken from the Ordnance Map.

The mines of the Audley, Coosheen, and Crookhaven Companies are adjacent to the line of section, and occur almost invariably at the junction of the green grits and purple slate; the ores being seldom or ever found in the latter, and, when they are, the gangue is generally green grit and quartz.

I have calculated the thickness of the purple slate and the green grit to be the following, in feet:—

Purple slate, ...	3864
Green grit, ...	1581

For building material, the red slate about Cork is selected in preference to the green grit.

January 11th, 1854.—Professor Haughton communicated the following Notices of Fossils from the Carboniferous Limestone.

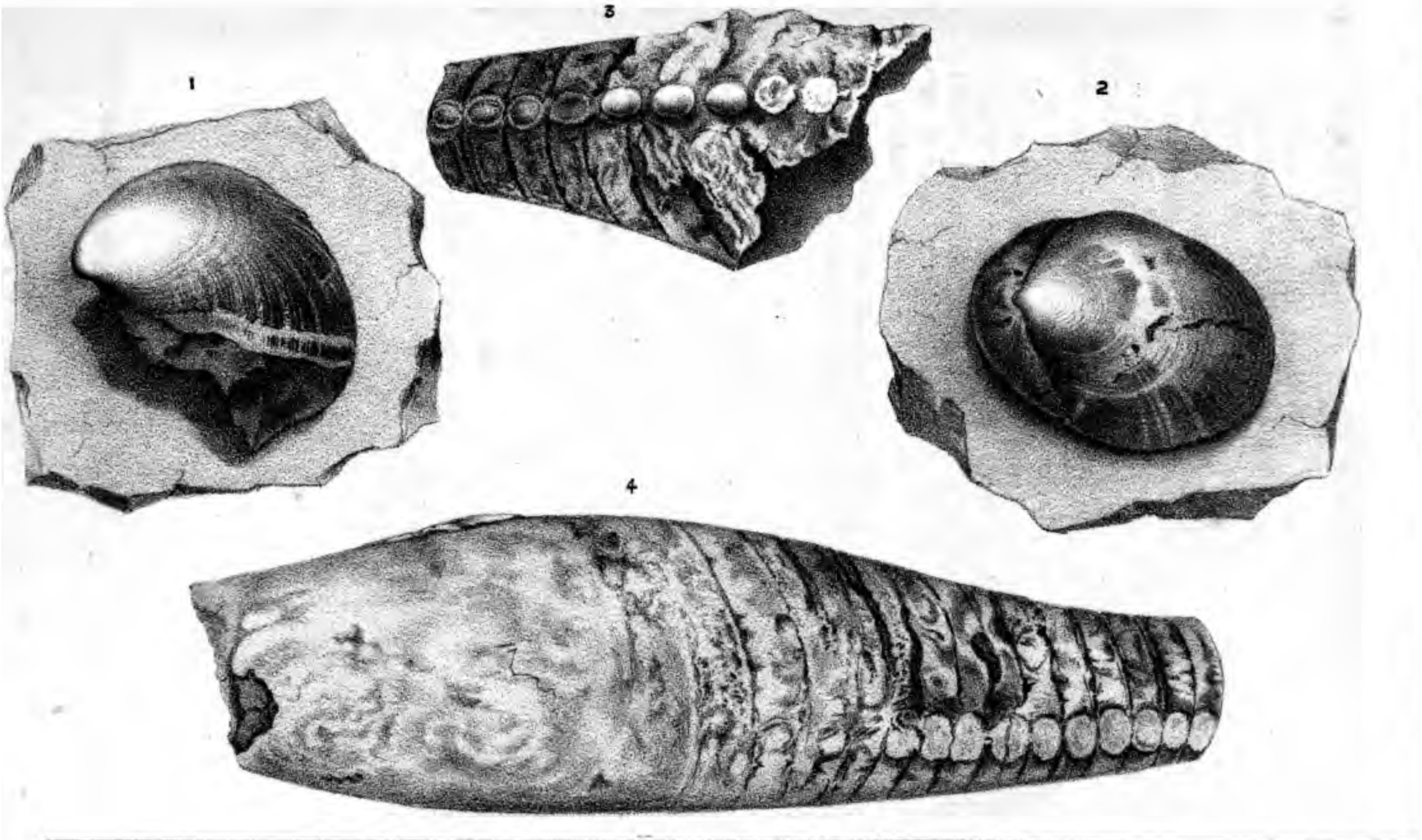
1. **Tragos semicirculare,** *M'Coy.*—This fossil is described by Professor M'Coy (Synopsis Carb. Foss. Ireland, p. 196, pl. xxvii. 8) as a zoophyte, probably allied to the family Spongiadæ. My attention was directed to it by Captain Jones, who, from a comparison of a specimen from the Kildare limestone, in Dr. Griffith's collection,

with his own collection of fishes' teeth from the Armagh limestone, was led to believe that it should be referred to the vertebrate, and not to the zoophytic, class. On a comparison of Captain Jones's specimens with Dr. Griffith's and another from Kildare, in the Museum of Trinity College, I believe that the *Tragos semicirculare* is identical with the *Cladodus striatus* of Agassiz.

2. **Atrypa hastata,** *Sow. sp.*—Two specimens of this fossil, showing the colouring of the original shell, are figured in the accompanying plate (Figs. 1, 2). The colouring matter appears to have been distributed in diverging rays of variable breadth: it appears on the figured specimens as a dark gray shading on the whitish blue of the shell. These specimens were presented to the Museum of Trinity College by George Dawson, Esq., and were found by him in the neighbourhood of Drogheda.

3. **Orthoceras unguis,** *Phil.*—Two specimens of this fossil are figured in the annexed plate: one (Fig. 3), found by the Rev. John Quarry at St. Doolagh's, Dublin; and the other (Fig. 4) by myself, at Llanedwen, Anglesey. The figures represent sections, showing the internal structure of the chambers and siphuncle; and from an inspection of them it appears that the siphuncle is beaded. From the specimens which I have had an opportunity of examining, I am inclined to believe that there is no sufficient reason for considering *Orthoceras arcuatum*, *Phil.*, to be distinct from the present. Mr. M'Coy has separated both these species from *Orthoceras*, and proposed for his new genus the name *Campyloceras*, derived from the curved outline of the fossil.

4. **Orthoceras fusiforme,** *Sow.* — From numerous sections of this fossil I have ascertained that it is provided with a beaded siphuncle, differing in no respect from that of *Orthoceras unguis;* it possesses, also, the curved outline of the latter, as is well shown by some beautiful specimens in the College Museum, found at Millicent, Kildare. I am strongly inclined to adopt the opinion that it should be considered the same fossil. Of the two figures given of it by Mr. Sowerby (Min. Conch., vol. vi., pl. 588), one would be called *O. unguis*, and the other *O. fusiforme*, by most geologists who recognise the difference between them. Mr. M'Coy has formed it, together with a new species (*ventricosum*), into a genus (*Poterioceras*), distinct from *Orthoceras*. If any new genus be formed, it should be one named from the beaded structure of the siphuncle,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AT THE

ANNUAL GENERAL MEETING

HELD ON

WEDNESDAY, FEBRUARY 8th, 1854,

THE PRESIDENT,—JOSEPH BEETE JUKES, ESQ.,

IN THE CHAIR,

The following Report from the Council was read and adopted:

THE Council present to the Society the following Report for the past year:

During the year *seventeen* new Members have been added to the Society, viz.:—*Life Members:*—Richard Purdy Allen, Esq.; Edward Barnes, Esq.; Professor Edward Forbes, F. R. S., President of the Geological Society of London; Professor Harkness, F. G. S.; William Bullock Webster, Esq.; and Andrew Wyley, Esq. *Annual Members:*—Rev. Harvey Ashworth; Stephen Woulfe Flanagan, Esq.; Henry Geoghegan, Jun., Esq.; George W. Hemans, Esq., C. E.; John Kennedy, Esq. (formerly an Associate); Henry Kingsmill, Jun., Esq.; John Stratford Kirwan, Esq.; John Locke, Esq.; George MacCartney, Esq.; Richard William Townsend, Esq., C. E.; and Robert Mackay Wilson, Esq.

The following *five* Associates have also joined during the same period, viz.: — John Grainger, Esq.; Joshua H. Lamprey, Esq.; Charles Newell, Esq.; Robert C. Smith, Esq.; and Edward Percy Wright, Esq.

The Society has lost during the year, from death and other causes, *ten* Members, viz.:—George A. Grierson, Esq.; John Hamilton, Esq.; Thomas Hamilton, Esq.; Edward Grattan Holt, Esq.; Thomas Maxwell Hutton, Esq.; Alexander Jack, Esq.; Samuel Jones, Esq.; Frederick M'Coy, Esq.; John Wallace, Esq.; and William T. Wilkinson, Esq.

Also *six* Associates, viz.:—Charles P. Cotton, Esq.; Arthur A. Jacob, Esq.; Alexander Mac Donnell, Esq.; John W. Mallet, Esq.; Joseph O'Kelly, Esq.; and William Thornhill, Esq.

The present state of the Society as to numbers is as follows:—4 Honorary Members, 43 Life Members, 85 Annual Members, and 14 Associate Members; total amounting to 146; being a gain on the year of *eight* Members.

This increase of Members has been accompanied by an increased interest felt by all in the progress of the Society, to meet which your Council have not hesitated to incur additional expense in illustrating your Journal; and they are happy to report that their exertions in this respect, accompanied, as they have been, by a reduction in the price of the old numbers of the Journal, have had the effect of rendering our publications better known among those interested elsewhere in our science.

In order to meet the increased desire of the Members for a speedy publication of our Proceedings, the Council have resolved on publishing the Journal, in future, twice each year; and they entertain the hope that the future numbers of your Journal will increase the reputation of this Society as an active centre of Geological Science. We cannot hope to compete with our elder sister, the Geological Society of London; but, in our own sphere, we may render essential service, by carefully recording the facts we have occasion to observe; at the same time it must be remembered, that in order to do so effectively by our publications, we must provide the means of publishing, which can be best accomplished by each Member persuading some of his friends to join, and unite with us in developing the mineral structure and resources of this country. Your Council are persuaded that the material basis of this country's prosperity depends upon the development of her agricultural and mineral resources. In this development the Geological Society of Dublin can take an active part; and it is a duty which we owe to ourselves to endeavour to increase the knowledge we possess, and to diffuse it. Our sphere may be humble, our place secondary, but let it be said of us that we have done what we could.

During the past summer the Third and concluding Part of Vol. V. of the Journal has been published, and with it a List of all Papers read before the Society since its foundation in 1831. The First Part of Vol. VI. will, it is hoped, be ready for delivery to the Members before the meeting in April.

The following List contains an account of the Donations made to the Society during the year.

DONATIONS

RECEIVED SINCE LAST ANNIVERSARY.

1853.

Feb. 16.—Memoir of the Right Hon. Sir John Sinclair, Bart. Presented by the Publishers, the Messrs. Chambers, Edinburgh.

Feb. 16.—Museum of Practical Geology and Geological Survey:—Records of the School of Mines and of Science applied to the Arts, Vol. I., Part 2. Presented by J. Beete Jukes, Esq.

Feb. 16.—The Isthmus of Darien in 1852.—Journal of the Expedition of Inquiry for the Junction of the Atlantic and Pacific Oceans, by Lionel Gisborne. Presented by H. C. Forde, Esq.

March 2.—Quarterly Journal of the Geological Society of London, No. 33. Presented by the Society.

March 2.—Museum of Practical Geology and Geological Survey:—Records of the School of Mines and of Science applied to the Arts, Vol. I., Part 1. Presented by J. Beete Jukes, Esq.

March 2.—Museum of Practical Geology.—Government School of Mines and of Science applied to the Arts:—Industrial Instruction on the Continent, by Lyon Playfair, C. B., F. R. S. Presented by J. Beete Jukes, Esq.

May 4.—House of Representatives.—William T. G. Morton, M.D.—Sulphuric Ether.—Report of the Select Committee on Dr. Morton's Memorial. Presented by the House of Representatives.

May 4.—Memoirs of the Geological Survey of the United Kingdom.—Figures and Descriptions illustrative of British Organic Remains. Decades IV. and VI.

1853.

May 4.—Museum of Practical Geology and Geological Survey:—Records of the School of Mines and of Science applied to the Arts, Vol. I., Parts 1 and 2. Museum of Practical Geology: Industrial Instruction on the Continent, by Lyon Playfair, C. B., F. R. S. Geological Survey of Great Britain, Sheets 17, 18, 60, 61; 72, N. E., S. W., S. E.; 74, N. W., S. W., S. E.; 75, 76, 77, N. E.; 78, N. W., N. E., S. W.; 79–82. Horizontal Sections, Sheets 18, 19, 20, 21, 23, 24, 26, 27, 28, 29, 30, 35, and 36. Vertical Sections, Sheets 16, 17, 18. The whole presented by the Geological Survey of the United Kingdom, through Sir Henry T. De la Beche, C. B.

May 4.—The Geological Observer, by Sir Henry T. De la Beche, C. B., &c. Second Edition, revised: 1853. Presented by the Author.

May 4.—1793 and 1853, in Three Letters, by Richard Cobden, Esq., M. P. Fourth Edition. Presented by the Peace Conference Committee.

May 11.—Transactions of the Royal Scottish Society of Arts, Vol. IV., Part 2. Presented by the Society.

June 8.—Quarterly Journal of the Geological Society of London, No. 34. Presented by the Society.

June 8.—Popular Physical Geology, by J. Beete Jukes, F. G. S. Presented by the Author.

July 8.—Transactions of the Kilkenny Archæological Society, for the year 1851. Presented by the Society.

Aug. 24.—Report of a Geological Survey of Wisconsin, Iowa, and Minnesota; and incidentally of a portion of Nebraska Territory: made under Instructions from the United States Treasury Department, by David Dale Owen; with a Volume of Illustrations. Smithsonian Contributions to Knowledge:—On Mosasaurus, and the allied Genera, by Dr. R. W. Gibbes. The Law of Deposit of the Flood Tide, by Charles Henry Davis, A. M., &c. Observations on Terrestrial Magnetism, by John Locke, M. D., &c. Memoir on the Extinct Species of American Ox, by Joseph Leidy, M. D. A

1853.

Flora and Fauna within Living Animals, by Joseph Leidy, M. D. Explanations and Sailing Directions to accompany the Wind and Current Charts, approved by Commodore Charles Morris, by Lieut. M. F. Maury, U. S. N. Fourth Edition. Report on the Geology of the Lake Superior Land District, by J. W. Foster and J. D. Whitney—Part 2, The Iron Region, together with the general Geology; with a Volume of Maps. Sixth Annual Report of the Board of Regents of the Smithsonian Institution, for the year 1851. On the Causes of Tornados, by Dr. Hare. Second Edition (three copies). Norton's Literary Register and Book Buyer's Almanack, for 1853 (two copies). The whole presented by the Smithsonian Institution.

Aug. 24.—Boston Journal of Natural History, Vol. VI., Nos. 1 and 2. Proceedings of the Boston Society of Natural History, Nos. 1 to 14. Presented by the Society.

Nov. 9.—Rough Notes of a Trip to Re-union, the Mauritius and Ceylon, by Frederic J. Mouat, M. D. Presented by the Author.

Nov. 9.—Athenæum.—Rules and Regulations, and List of Members, 1852; with Donations to the Library. Annual Report; General Abstract of the Accounts, &c., from 1st January to 31st December, 1853. Presented by the Club.

Dec. 13.—Quarterly Journal of the Geological Society of London, No. 36. Presented by the Society.

Dec. 13.—The Queen's University in Ireland:—Report on the Condition and Progress of the Queen's University in Ireland, for the year ending June 19, 1852, and to September 1, 1853; A.B. and A. M. Degree and Honor Examination Papers, 1853 (two parts); Agriculture Diploma and Honor Examination Papers, 1853; List of the Senate, Professors, and Examiners; and Ordinances regarding the several Courses of Study. Presented by the Secretary, Robert Ball, LL. D.

1853.

Dec. 13.—The Medical Circular, No. 46, New Series. Presented by the Editor.

1854.

Jan. 11.—Proceedings of the Royal Irish Academy, Vol. V., Parts 2 and 3. Presented by the Academy.

Jan. 17.—Arrangement of the British Marbles, Alabasters, Serpentines, Porphyries, Granites, Building Stones, &c., in the Vestibule and Hall of the Museum of Practical Geology, 1853. Museum of Practical Geology and Geological Survey:—Records of the School of Mines and of Science applied to the Arts, Vol. I., Parts 3 and 4. Presented by the Geological Survey of the United Kingdom, through Sir Henry T. De la Beche, C. B.

Feb. 8.—The Athenæum, 1853. Presented by the Editor.

Feb. 8.—The Literary Gazette, 1853. Presented by the Editor.

Feb. 8.—Journal of the Society of Arts, Nos. 12 to 63. Presented by the Society.

Feb. 8.—The Musical Times, Nos. 106 to 117. Presented by the Editor.

Feb. 8.—A Monograph of the Crag Mollusca, or, Descriptions of Shells from the Middle and Upper Tertiaries of the East of England; by Searles V. Wood, F. G. S., Part 1, Univalves (two copies). Monograph on the Fossil Reptilia of the London Clay, Part 1, Chelonia, by Professor Owen, F. R. S., &c., and Professor Bell, Sec. R. S., &c. 4to. London: Printed for the Palæontographical Society, 1848–49. Presented by William Edington, Esq.

Feb. 8.—Quarterly Journal of the Geological Society of London, No. 35. Presented by the Society.

Feb. 8.—Address at the Anniversary Meeting of the Royal Geographical Society, 23rd May, 1853, by Sir R. I. Murchison, G. C. St. S., &c. Presented by the Author.

Feb. 8.—Thirty-third Report of the Council of the Leeds Philosophical and Literary Society, at the close of the Session, 1852–53. Presented by the Society.

1854.

Feb. 8.—Memoirs of the Geological Survey of the United Kingdom—Figures and Descriptions illustrative of British Organic Remains, Decade VII. Museum of Practical Geology and Geological Survey—Records of the School of Mines and of Science applied to the Arts, Vol. I., Parts 3 and 4. Board of Trade—Department of Science and Art—Prospectus of the Metropolitan School of Science applied to Mining and the Arts, 3rd Session, 1853–54 (two copies). On the Educational Uses of Museums, by Edward Forbes, F. R. S., &c. The whole presented by the Geological Survey, through J. B. Jukes, Esq.

Feb. 8.—Reports of the Proceedings of the Geological and Polytechnic Society of the West Riding of Yorkshire, 1852. Presented by the Society.

LIFE SUBSCRIPTIONS.

	£	s.	d.
Lord Talbot de Malahide,	10	0	0
Rev. Professor Haughton,	10	0	0
Richard Purdy Allen, Esq.,	10	0	0
Robert Harkness, Esq.,	10	0	0
Edward Barnes, Esq.,	5	0	0
William B. Webster, Esq.,	5	0	0
Andrew Wyley, Esq,	5	0	0
	£55	0	0

ADMISSION FEES.

	£	s.	d.
Samuel Gordon, M. D.,	1	0	0
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John S. Kirwan, Esq.,	1	0	0
Professor England,	1	0	0
William Scott, Esq.,	1	0	0
Stephen W. Flanagan, Esq.,	1	0	0
Richard Wolseley, Esq.,	1	0	0
William Clarke, Esq.,	1	0	0
Rev. H. Ashworth,	1	0	0
	£9	0	0

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James Duncan, M. D.,	1	0	0
A. Jack, Esq.,	1	0	0
Robert Callwell, Esq.,	1	0	0
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Rev. Charles Graves,	1	0	0
A. M'G. Giles, Esq.,	1	0	0
George Yeates, Esq.,	1	0	0
George M'Dowell, Esq.,	1	0	0
Charles P. Croker, M.D.,	1	0	0
Joseph Welland, Esq.,	1	0	0
Earl Fitzwilliam,	2	0	0
Carried forward,	£17	0	0

	£	s.	d.
Brought forward,	17	0	0
John S. Kirwan, Esq.,	1	0	0
H. Medlicott, Esq.,	1	0	0
John J. S. Moore, Esq.,	1	0	0
Gilbert Sanders, Esq.,	1	0	0
John Purser, Esq.,	1	0	0
Thomas Hutton, Esq.,	1	0	0
John M'Donnell, M.D.,	1	0	0
John Patten, Esq.,	1	0	0
Pat. Fenlon, Esq. (1852–53),	2	0	0
Samuel Downing, Esq.,	1	0	0
Robert Ball, Esq.,	1	0	0
R. Hitchcock, Esq.,	1	0	0
Evelyn Shirley, Esq.,	1	0	0
Professor England,	1	0	0
Frederick M'Coy, Esq.,	2	0	0
Carried forward,	£34	0	0

	£	s.	d.
Brought forward,	34	0	0
George Kinahan, Esq., . .	1	0	0
Wm. Thomas Wilkinson, Esq.,	1	0	0
Henry H. Head, M. D., . .	1	0	0
James Apjohn, M. D., . .	1	0	0
Richard Wolseley, Esq., . .	1	0	0
William Clarke, Esq., . .	1	0	0
The Lord Chancellor (1852–53)	2	0	0
The Rev. the Provost, . .	1	0	0
William Scott, Esq., . . .	1	0	0
Robert Harrison, M. D., . .	1	0	0
Stephen W. Flanagan, Esq.,	1	0	0
William Edington, Esq., .	1	0	0
Rev. J. Galbraith, ...	1	0	0
The Lord Talbot, ...	1	0	0
Rev. J. H. Jellett, ...	1	0	0
Earl of Bective, ...	1	0	0
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M. M. O'Grady, M. D., . .	1	0	0
Charles W. Hamilton, Esq.,	1	0	0
Frederick J. Sidney, Esq., .	1	0	0
John Radcliffe, Esq., . . .	1	0	0
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H. W. Allen, Esq., . . .	1	0	0
Rev. C. W. Wall, ...	1	0	0
Rev. W. A. Willock, . . .	1	0	0
Rev. A. B. Rowan, ...	1	0	0
Dr. Allman, ...	1	0	0
M. D'Arcy, Esq., ...	1	0	0
Archbishop of Dublin, . . .	1	0	0
Earl of Leitrim, ...	1	0	0
John Petherick, Esq., . . .	1	0	0
Thomas Hamilton, Esq., . .	1	0	0
W. H. Curran, Esq., . . .	1	0	0
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	£	s.	d.
Brought forward,	69	0	0
J. B. Doyle, Esq., ...	1	0	0
Rev. H. Lloyd, ...	1	0	0
B. D. Gibbons, Esq. (1852–53), ...	2	0	0
R. M. Wilson, Esq., . . .	2	0	0
Rev. H. Ashworth, . . .	1	0	0
Richard Griffith, Esq., . .	1	0	0
H. Bruce, Esq., ...	1	0	0
Dr. Mollan, ...	1	0	0
Francis Codd, Esq., . . .	1	0	0
William Dawson, Esq., . .	1	0	0
Dr. Whitty, ...	1	0	0

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	£	s.	d.
Thomas M'Comas, Esq., . .	0	5	0
Joseph Kincaid, Esq., . . .	0	5	0
A. A. Jacob, Esq., ...	0	5	0
John Kennedy, Esq. (Composition), ...	0	10	0
Arthur Jacob, Jun., Esq., .	0	5	0
John Haughton, Esq., . . .	0	5	0
John Mallet, Esq., ...	0	5	0
Jones Pigot, Esq., ...	0	5	0
J. K. Reid, Esq., ...	0	5	0
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Joseph Kincaid, Esq., . . .	0	5	0
R. C. Smith, Esq. (1854), .	0	5	0
John S. Maguire, Esq. (1854),	0	5	0
	£86	10	0

ABSTRACT OF THE TREASURER'S ACCOUNT FOR THE YEAR ENDING FEBRUARY, 1854.

Dr.

1853.		£ s. d.
To Balance of last Year's Account, ...		2 11 5½
— Received for Iron Frames purchased by Mr. Downing, ...	£0 4 0	
Ditto, by Mr. Haughton, ...	0 6 0	
		0 10 0
— Received for Journals sold, ...		3 11 6
— „ Life Subscriptions, ...	£55 0 0	
— „ Admission Fees, ...	9 0 0	
— „ Annual Subscriptions, . . .	86 10 0	
		150 10 0
— Balance due to the Treasurer, ...		31 9 5½
		£188 12 5

Cr.

Date	Particulars		£ s. d.
1853.			
Mar. 16.	—By paid Assistant Secretary's salary to 14th February, ...	£10 0 0	
	— Servant's wages, ...	1 10 0	
	(per Draft 8820)		11 10 0
	— Paid Mr. Waller's account for Engraving (per Draft 8821), ...		13 0 0
May 4.	—By paid for Furniture, ...	£10 0 0	
	— „ Sundries, per Assistant Secretary's book, ...	7 16 2	
	(per Draft 8822)		17 16 2
June 15.	—By paid Mr. Oldham, in part of his account for Engraving (per Draft 8824), ...		10 0 0
Nov. 2.	—By paid Assistant Secretary's salary to 14th August, ...	£10 0 0	
	— Paid for sundries, per book, . .	12 12 8	
	(per Draft 8825)		22 12 8
„ 16.	—By paid Mr. Oldham, balance of his account for Engraving (per Draft 5126), ...		3 0 0
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ANNUAL ADDRESS

DELIVERED BEFORE THE

GEOLOGICAL SOCIETY OF DUBLIN,

FEBRUARY 8, 1854,

BY

JOSEPH BEETE JUKES, M.A., F.R.S.

PRESIDENT OF THE SOCIETY.

YOU will doubtless recollect, Gentlemen, that when our late President, Dr. Ball, prematurely resigned the office last year, induced thereto, to our great regret, by ill health and pressure of other business, he said that he left it as a debt due by the Chair to review the sixteen papers which were laid before you during the year of his presidency, and trusted to me to clear it off on the present occasion.

I should at all times, Gentlemen, be most anxious to comply with any wish of my friend Dr. Ball, and will therefore endeavour to meet the spirit, if not the precise words, of his request, by taking as the subject of the present Address not merely our own progress but the general progress of Geology during the past two years. As, however, this is too large a subject to be compressed into so short a space with any hope of justice being done to it, and as time and means would alike fail me in making this review a general one for the whole world, you must allow me to confine myself chiefly to our own islands, and even then to select from the publications of the last two years such as appear to me to be of the most general interest. Among these I shall hold as the chief the publications of our great prototype, the Geological Society of London. I will endeavour then, in addition to a notice of our own works, to give you a brief account of what they have been doing, and of one or two other contributions to our general knowledge; and I think perhaps I

may thus more usefully occupy your time than if I confined myself to reciting and criticising that with which you ought to be already sufficiently familiar,—namely, the papers which have been read at our own meetings.

In reviewing the publications of the Geological Society of London I shall include the two Presidential Addresses for 1852–53, because they contain very valuable contributions to our stock of general information on two subjects of great interest and importance. When I remind you that their author is the eminent Cambridge mathematician and physicist, Mr. W. Hopkins, you will at once be aware of the value of these contributions.

GEOLOGICAL PHYSICS.

In his Address of last year Mr. Hopkins has done a great service to all those of us who have not the time to read large and profound books, and who do not possess much mastery of the language and processes of mathematics, by giving us a popular account of the great work of M. Elie de Beaumont on "The Systems of Mountain Chains." Mr. Hopkins speaks in the highest terms of the great ingenuity, the perfect acquaintance with the mathematics of the subject, the care and labour bestowed on elaborating all the details, the unflinching honesty which leaves no part of the subject without complete investigation, and the candour of statement displayed by the eminent author of this great work.

In endeavouring to condense Mr. Hopkins's account of it, and to reduce his description into still more familiar terms, I fear I must be led into some inexactness or incompleteness of statement; but all I aim at is to give you such a clue to the general bearings of the subject as may induce you to give and facilitate your giving a careful and patient perusal to Mr. Hopkins's Address, and thus enable you to make yourselves more complete masters of the theory of M. Elie de Beaumont.

You are aware that the main point of this theory is to prove that those mountain chains that run parallel to each other have been elevated at the same time, or rather, perhaps, that all mountain chains of contemporaneous elevation run parallel to each other. Now, in the first place, what do we mean, when we speak of the globe generally, by mountain ranges being *parallel* to each other? It is obvious that when we take comparatively small portions of the earth's

surface, such as England and France, or France and Spain, that the compass-bearing will give us a sufficiently accurate measure of parallelism. A mountain chain running N. E. and S. W. in England will be parallel to a N. E. and S. W. chain in France, with quite sufficient accuracy for our purpose. If, however, we take a terrestrial globe, and draw on different portions of it widely apart from each other lines representing mountain chains, each running N. E. and S. W. (of course I mean corrected for the variation of the compass), you will see that these different lines are by no means *parallel* to each other in any sense in which that term could possibly be applied.

Suppose we draw such a line, say a thousand miles long, passing through London, and another through the antipodes of London, and the globe were transparent, and we were to hold it up to the light in such a position as to make those two points coincide, we should see that the N. E. and S. W. lines, instead of being parallel, crossed each other at right angles. In the same way, in a terrestrial globe, all the meridians have the same compass-bearing—namely, due N. and S.; but instead of being parallel, they all converge at the poles, where they cross each other at all kinds of angles. That lines having the same compass-bearing are not parallel to each other may be shown also in this way:—Suppose the globe to be all covered with water, and the variation of the compass not to exist, and a vessel in the Antarctic regions were to start on an E. N. E. course, it is clear she would sail round and round the globe, continually getting farther north until she found herself in the Arctic regions, having thus described a great spiral round the globe of several turns; but no part of a spiral can be considered as *parallel* to any other part.

Again—the meridian lines on a globe are all great circles; that is, if we suppose the earth to be cut through by a plane coinciding with any meridian line, that cut would pass through the centre of the earth, and the globe would be divided by it into two equal parts, or two hemispheres: and when we consider the matter, we shall see that no two planes, each of which coincides with a great circle, can be parallel to each other. If we cut an orange into two halves, and then divide it again into slices by cuts parallel to the first, these slices will be smaller and smaller as they recede from the first, and none of them can by possibility pass through the centre

of the orange except the first: in other words, all the parallel planes cutting through the orange except the first must form small circles, and only one can produce a great circle.

Again—if we travel round the globe, keeping on the circumference of a great circle, we shall, on all such circles except the equator, be continually altering our compass-bearing. Suppose we travel along the circle called the Ecliptic. If we started on the equator, at the point called the vernal equinox, and proceeded in to the northern hemisphere, we should set out on a course running nearly E. N. E.; but when we had proceeded nearly a quarter round the globe, and were approaching the tropic of Cancer, we should have gradually fallen off from that course into one nearly due E., and for a short space, as we actually touched upon the tropic, our course would be really east. We should then commence returning towards the equator, and as we crossed it at the autumnal equinox our course would be E. S. E.; again getting more easterly as we advanced into the southern hemisphere, becoming due east at the tropic of Capricorn, and returning to the point we started from in an east-north-east direction, as before. Still, although our compass-bearing thus altered, we may see that every portion of the circumference of this great circle called the ecliptic must be considered parallel to every other portion when we look at it as the edge of a great plane cutting through the centre of the earth. We see, then, that lines having the same compass-bearing (unless they are east and west lines, or parallel to the equator), are not at all parallel to each other if they are removed by any considerable portion of the earth's surface; and that lines which are strictly parallel to each other, when we look at the earth *ab extra*, as it were, do not always preserve the same compass-bearing.

Now M. Elie de Beaumont's definition of what he means by parallel chains is, that those chains are parallel to each other which can be shown to be parts of small circles which are parallel to the same great circle. If, for instance, there were a number of mountain chains in different portions of the earth running in such directions that the lines representing them on a terrestrial globe could, if continued, be made to form parts of different small circles, all parallel to the great circle of the ecliptic, those mountain chains would be considered by M. de Beaumont as parallel to each other, and forming one system of mountains.

Recurring to the orange for the sake of illustration, if we cut it in any direction clean through the middle, and then slice it by a number of cuts parallel to the first, the lines described by these cuts on the surface of the orange would represent a system of parallel mountain chains, according to M. de Beaumont,—the first cut being the great circle to which all the rest are referred.

In order then to decide whether any two or more mountain ranges are parallel to each other, he first ascertains whether lines drawn through their middle point, at right angles to their general course, will cut the same great circle at right angles, or, in other words, whether they can be considered as forming parts of small circles parallel to the same great circle. This great circle he calls the great circle of comparison, or great circle of reference of each system. This explanation, I believe, is sufficiently exact to enable us to understand what M. E. de Beaumont means by *parallel systems of mountain chains.* He asserts that all the mountains of each system were contemporaneously elevated,—meaning, I believe, to take the term contemporaneous in its strict sense, as referring to the same instant of time. Mr. Hopkins justly remarks that this strictness "is not essential to M. de Beaumont's mechanical views on the subject, and his theory of parallelism may be as applicable to the result of a *succession* of movements during a *comparatively* short, definite period as to the effects of a single movement. Some of the movements might reasonably be supposed to have been sufficiently energetic to stamp at once their impress on the geological character of each district; but I see no adequate reason why the theory should altogether reject the idea of subordinate movements in the same system."

Having described M. de Beaumont's idea of parallelism, Mr. Hopkins also examines the descriptive part of his work, where he applies it to the observed directions of different ranges of mountains. Of these M. de Beaumont reckons twenty-one systems, principally founded on observations made in Europe, though supposed to be applicable to mountains in other parts of the globe. Of this part of M. de Beaumont's work Mr. Hopkins justly observes, that it is necessary very carefully to discriminate between those systems of mountain ranges, the elevation of which is proved to have been contemporaneous by *geological evidence independent of the theory,* and

those whose contemporaneity is held to be proved in consequence of their parallelism.

It is obvious that for the theory to rest upon any secure basis of observed fact, it is necessary for the number of cases where the contemporaneity of parallel systems of mountains is proved by independent geological evidence to be very large in proportion to the number where they are only assumed to be contemporaneous because they are parallel.

Mr. Hopkins discusses the evidence adduced in support of each of the twenty-one systems mentioned by M. de Beaumont. In many of these the geological time of their elevation, even where that rests on evidence independent of the theory, is still indeterminate by reason of the want of the complete and accurate determination of the exact age of some of the rocks affected; in others, it is probable that the line of elevation is rather a local deviation, resulting, perhaps, from disturbances of a subsequent period than a normal direction of a mountain chain. In others, again, a distinct epoch of elevation is assigned to periods, such as one between the mountain limestone and the millstone grit, or between the millstone grit and the coal-measures,—divisions which have only a local and partial existence, and between the formation of which I know of no evidence from any independent geological characters proving any interval or any discontinuity to have occurred. Others again of M. de Beaumont's lines are curved lines, which he accounts for by supposing a mixture of systems, or one movement modified by another; and again he splits up some districts, showing *parallel curved* lines of elevation, to assign them to different systems, widely apart geographically, and with which there is no other evidence of connexion than this parallelism. Unless I were to literally copy a large portion of Mr. Hopkins's Address, it would be impossible for me to do justice to this portion of the subject; I must therefore refer you to that Address itself.

There is a second portion of M. de Beaumont's theory quite independent of the first, of which I will try to give you a very brief description:—Assuming the first part to be true, namely, that there are many systems of contemporaneous parallel mountain chains, all those of each system being parallel to one great circle of reference, he endeavours to discover, whether these great circles of reference have

not some symmetrical relation one to the other; and if so, what that relation is.

In this part of his theory M. de Beaumont seems to deal still more largely in assumptions than in the former part. He appears, with much labour, to have calculated and tabulated the angles at which *the directions* of his great circles of reference cross each other, and to have been struck with an occasional appearance of symmetrical relation between one group of them seeming to approximate in direction, and another group which seemed to have a tendency to cross the former perpendicularly; so that there were alternations of groups and gaps between the lines. It appeared also that there was an occasional recurrence of the same angle, as for instance that of nearly 22°, between the directions of several pairs of great circles of reference. In endeavouring to discover what the relation was, however, it appears to me clearly that M. de Beaumont has *selected* such a geometrical system as gave the greatest number of relations of symmetry with which to compare the supposed relations of his great circles of reference; so that the probability of the latter coinciding with some of the former became very high. M. de Beaumont adopts a geometrical system of lines, founded on the pentagon, and calls it a "reseau pentagonal," or pentagonal network.* It is possible to draw fifteen great circles on the globe at such angles, and in such positions, that they shall divide its whole surface into twelve equal pentagonal spaces, so arranged that two of these pentagons shall be exactly opposite to each other, and shall be each surrounded by five others, which shall have each one side in common with one of the others. M. de Beaumont then proceeds to bisect each of the sides of these pentagons, and joining the nearest points of intersection by lines, which can be extended into other great circles, he forms other regular pentagons inside the first set; and again, by joining the alternate points of intersection by lines which are likewise to be extended into great circles, he forms another still interior set of pentagons; and again, by joining other points of intersection which arise during this pro-

* This portion of M. E. de Beaumont's theory has already been described to you by my able predecessor, Colonel Portlock, in his first Address. I have, however, thought it better not to omit Mr. Hopkins's views of it, both because he differs from Colonel Portlock in his estimate of its real value, and in order to lay before you a connected account of the whole of M. de Beaumont's theory.

cess, he gets many other sets of great circles, all having a certain symmetrical relation to the first set, until the whole sphere can be covered by a network of ever increasing complexity. It is true that M. de Beaumont assigns certain numerical values to these different sets of great circles, reckoning the more simple and earlier ones at much higher rates than those of later result: still, even these values are assigned arbitrarily.

He then tries graphically on a globe, with such a pentagonal network made of fine thread, whether it was possible to find any point, in Europe for instance, where, by making it the centre of his pentagon, he could turn that network about till some of the principal lines of it should coincide with the directions of some of his observed systems of mountain chains. He finds such a point near Remda, in Saxony; and by making that the centre of his pentagon, and making one of the lines of his network coincide with one of the lines of the mountain systems, he finds that the lines representing the direction of the great circles of reference of ten other systems pass through this point.

Mr. Hopkins, however, shows that it necessarily follows from one of M. de Beaumont's assumptions that many of the great circles of reference should meet, or nearly meet, somewhere in Central Europe, and that the complicated nature of the pentagonal network is such that the same result of *approximate agreement* would necessarily be found for any sets of circles drawn completely at random. He therefore, though with much reluctance, decides in his own mind against the establishment of the "reseau pentagonal," while giving, at the same time, high praise to the author for his ingenuity, for his industry, and for the profound knowledge displayed by him in his work.

The physical cause involved in M. de Beaumont's theory is, that the phenomena of elevation are the result of the shrinking of the earth's crust, arising from the refrigeration of the interior, supposed to be, or to have once been, in a state of fusion.

While agreeing to a certain extent in the probability of the cause, Mr. Hopkins remarks, that he would have great difficulty in tracing to it the sudden and violent actions contended for by M. de Beaumont, and would rather expect from it a gradual action, with occasional slight and frequently recurring paroxysmal starts, in accordance with the gradual nature of the process of refrigeration.

Finally, Mr. Hopkins sums up by saying that M. De Beaumont's theory cannot be accepted, as proved by *a priori* reasoning, but must be judged hereafter by its accordance with observed fact,—remarking, "that the phenomena of elevation, within certain districts, are usually connected by some geometrical law; and that such law is frequently that of parallelism I conceive to be beyond all doubt; and moreover, I think it almost equally beyond reasonable doubt that the phenomena thus connected may be considered as contemporaneous, not necessarily, in M. De Beaumont's absolute sense of the term, but at least as regards the principal of those movements to which the phenomena are referable. That the law of parallelism, however, especially as restricted to *straight* lines alone, is the only law which may characterize a system of lines of elevation, I cannot admit. The law of *divergency* may in some cases be distinctly recognised, as in the lake district of the north of England."

In short, gentlemen, it appears to me that our knowledge may be roughly summed up as follows:—Forces of elevation seem in some instances to have acted on points, producing dome-shaped elevations and diverging cracks; sometimes on lines, producing linear elevations and cracks; sometimes on spaces having both length and breadth, when parallel elevations and depressions have been produced, running in the direction of the *length* of the district, and having cracks both longitudinal and transverse. It appears probable, moreover, that the linear and the dome-shaped elevation have sometimes been combined so as to have modified each other, and it is obvious that the ends of a linear elevation must always have more or less of a semi-dome-shaped or apse-like structure. Lastly, it appears to me that M. De Beaumont's theory is too complete and too neat and precise, as well as too complex, if not for nature itself, at all events for the present state of our knowledge of nature; and that, though far too important a theory to be lost sight of, it must still remain a problem to be solved by observation rather than be received into our science as a guiding rule to aid us in observing.

The next subject of which I shall endeavour to give you a brief account is one treated of by Mr. Hopkins in a paper, and in his published Address in the early part of 1852. The paper is "On the Causes which may have produced Changes in the Earth's superficial Temperature;" and the principal subject of the Address is on "The

Drift," the origin of which the paper is chiefly intended to explain. Mr. Hopkins divides his paper into two parts: the first is "*on the influence of the earth's internal heat, and of the heat radiating from external bodies on the earth's superficial temperature.*" He establishes the following data to commence with:—

1. The mean annual temperature of the surface of the earth equals that of the air close to it.

2. The mean annual temperature below the surface is the same down to the depth of 60 or 70 feet, the oscillations felt at the surface becoming less and less as we descend, until at about that depth the mean temperature would be constant.

3. At depths greater than 60 or 70 feet the temperature is constant, and increases directly as the depth.

4. The temperature of any part of the earth's surface now is due partly to the remains of the earth's primitive heat (supposing that internal temperature to have existed) and partly to the heat received from the sun during the whole term of the earth's refrigeration. Now Poisson has shown that the remaining effect of the earth's internal heat, at the surface, is certainly not greater than $\frac{1}{20}$° Fahrenheit, and that the refrigeration must have been so slow that an enormous series of millions of years has elapsed since the internal heat exerted an effect of 1° on the surface; moreover, as the increase of temperature now is equal to 1° of Fahrenheit for every 60 feet of descent, when the effect of the internal heat amounted to 1° at the surface, the rate of increase must have been 20° for every 60 feet of descent, and when the superficial effect of the internal heat was equal to 10°, we should have, at a depth of 60 feet, a temperature of 200° at least, with an increase of 200° for every sixty feet of descent. All except surface springs then must have been boiling water, and animal life perhaps impossible. It follows from this, as it appears to me, that as we have some of the older rocks, for instance, some Silurian rocks, still unaltered by heat, and in the condition of soft clays and incohærent sandstone, the refrigeration of the earth's surface (supposing it to have been once fused) must already have reached nearly its present limit, at the very early period of the deposition of those Silurian rocks, for we can hardly suppose it possible that there is any Silurian rock which has not, either at the close of the Silurian period or during some paleozoic era, been buried under many hundreds, if not many thousands, of

feet of other accumulations, and therefore if at any of those periods the superficial effect of the internal heat were 1°, and its rate of increase 20° for every 60 feet of depth, such portions must have been brought within reach of a very high temperature, sufficient at least to have affected soft clays and sands full of lime, and other materials likely to act as fluxes.*

5. The fifth conclusion established by Mr. Hopkins is, that any effect arising from internal heat could only be one of gradual refrigeration, and could not produce any oscillations of temperature.

He then discusses the question of the possibility of the temperature of the earth's surface being increased by the near approach of the solar system (in consequence of its own proper motion) to any other body, such as a star; he shows the extreme improbability of this, and also that neither from this source should we get any *oscillation* of temperature, as, although a star might be a centre of heat, we do not know of any centres of cold.

The second part of Mr. Hopkins's paper is "*On the influence of various configurations of land and sea, and oceanic currents on the earth's superficial temperature.*"

In this part, taking as his guide the admirable and useful maps of isothermal lines by Dove, he discusses the cause of the well-known but extraordinary deviation from their normal course of the isothermals in the west of Europe, examining what would be the effect of each of the following hypotheses:—

1. Configuration of land and sea as at present, but no gulf stream.

2. Gulf stream as at present, but a solid barrier of land from Scotland to Ireland and Greenland.

3. All the north Atlantic converted into land, and Europe joined to America.

4. Large parts of North America and Europe submerged, and the gulf stream diverted into some other course.

He inquires what would be the probable positions of the summer andwinter is othermals in each of the above hypothetical cases; describes what is known as to the present level of the snow-line and

* As one locality where this must have occurred, I may instance the part of Shropshire west of Wenlock Edge, where the Wenlock shale and upper part of the Caradoc sandstone must have been covered by all the Ludlow rocks at least, and most probably by the Old red sandstoneand Coal-measures.

the limits of the descent of glaciers, and what their probable levels would be in each of those hypothetical cases; and lastly examines the relative claims that those four hypotheses have on our acceptance.

On the first hypothesis, that of the configuration of land and sea being as it is now, but the gulf stream being absent, we should have the following results:—The January isothermal of 32°, instead of running, as it does now, from Holland to the coast of Norway, would strike from central Europe through the west coast of Brittany; and that of 23° would cross through the middle of England and Ireland, about the latitude of Dublin, instead of running, as it does now, through the gulf of Finland and Lapland to the North Cape, and thence between Iceland and Greenland.

On the summer isothermals, on the contrary, the absence of the gulf stream would have but little effect, since the temperature of the North Atlantic and of Western Europe is naturally raised by the summer sun to a point above that of the gulf stream, which therefore cannot raise it any higher. The July isothermal of 63°·5, for instance, which passes just south of London, would pursue exactly the same course it does now if the gulf stream were taken away, and the others would be nearly parallel to it. On this hypothesis, then, we should have the same summers we have now, but the winters of Lapland or the Labrador, with all our seas frozen over. The farther we go north the greater would be the effect of this abstraction of the gulf stream on the *mean annual* temperature. About the Alps this would not be lowered more than 2°, about Snowdon it would be lower by $7\frac{1}{2}$°, in the north of Scotland by $12\frac{1}{2}$°, and in Iceland by 18°.

On the second hypothesis, the gulf stream remaining, but land connecting Scotland and Greenland, we should have the effect of the gulf stream concentrated in the North Atlantic; the January isothermals would run nearly N. and S. from Iceland to Central France, while Scandinavia, being deprived of the effects of the gulf stream, would have its winter temperature greatly diminished, and its mean annual temperature considerably lowered.

On the third hypothesis, namely, dry land stretching from Europe to America, the isothermal lines would preserve their parallelism as in Central Asia, running in straight lines, or nearly so. In that case, the January isothermal of 32° would run nearly

E. and W., not far from the parallel of 40°, or about the latitude of Constantinople, Naples, Madrid, and Pennsylvania, and the winter isothermals of 23°, 14°, and 5°, which in Central Asia and Central America are nearly parallel to 32°, would be continued parallel throughout their course, that of 5° passing through the S. of England, and altogether S. of Ireland. This would be tantamount to giving us the winter temperature of Tartary and Siberia, Nova Zembla, Spitzbergen, Greenland, and Hudson's Bay. On the summer isothermals the effect of converting the Atlantic into dry land would be to draw them also into straight lines, bringing the northern ones more south, and the southern ones more north. The total effect on the mean annual temperatures of the same places, as before, would be a diminution—

At the Alps, of	11°
At Snowdon, of	20°
At the North of Scotland, of	26°
At Iceland, of	25°

The fourth hypothesis, namely, all the low land of Europe converted into sea, and the gulf stream absent, gives us the case of the glacial sea,—a case especially interesting to geologists, as being the conditions under which we believe the drift to have been formed.

Mr. Hopkins examines the probabilities under this hypothesis in some detail; but it may be sufficient if I say here, that the results arrived at are very much in accordance with those in the first hypothetical case, modified by the effects which a preponderance of sea over land would produce,—namely, the equalization of extremes, the lowering of southern, and the raising of northern temperatures. The isothermal lines would probably run, as before, nearly straight, the January one of 32° cutting the coast of France a little south of where it was placed under the first hypothesis, and the others following, so as to lower the mean annual temperatures of the places mentioned before by 2° or 3° more than by the first hypothesis, principally from the diminution of heat during the summer.

Mr. Hopkins then investigates the question of the height of the snow-line and the descent of glaciers generally, and for each of the above hypotheses. The snow-line is that line where snow is permanent throughout the year: it therefore depends on the *summer* temperature, and not on the mean annual temperature. The snow-line

will therefore be lowest where there is greatest humidity to cause the deposition of snow, and the temperature is most equable, or where the extremes of summer heat vary least from the mean. For this reason the snow-line will not always coincide with the line where the mean temperature is 32° Fahr.

From the result of observations, it appears that we may take a decrease of 1° F. as corresponding to elevations varying from 320 to 500 feet,—the smaller number being that of ascents in balloons, and up the sides of very steep, isolated mountains; the larger, of a succession of swelling table lands and wide-spread mountain ranges. If, therefore, we know the mean temperature of any place at the level of the sea, and the nature of the rising ground, we can calculate the height at which the mean temperature of its highlands would be 32°.

From Humboldt's observations, it appears that at Chimborazo the mean temperature of the snow-line is 34°·7; at St. Gothard it is 25°·3; and under the Polar Circle, 21°·2: in other words, the snow line is 1000 feet lower than the line of 32° at Chimborazo, 2000 feet above it at St. Gothard, and 3500 feet above it under the Polar Circle. In N. E. Asia, from the defect of moisture and the continental or excessive climate (as to summer heat), the height of the snow-line is probably still higher above that of 32°, while in Iceland, from its insular situation, combining humidity with equability of temperature, the snow-line coincides with that of 32°. It is important to recollect that other conditions remaining the same, the conversion of a continent into an archipelago of islands lowers the height of the snow-line.

The vertical descent of glaciers below the snow-line will depend on the thickness of the glacier, the rate of its motion, arising from the steepness or otherwise of its bed, and the activity of the destructive agencies to which it is exposed. Observations on the great glaciers of the Alps give a mean of about 4500 feet for the vertical descent below the snow-line, and with this result some of those of the Himalayah and other mountains in different parts of the world sufficiently coincide.

Starting with these data, Mr. Hopkins shows, that supposing the climate of Western Europe to have been as it is now, and simple elevation of the land to have taken place, it would be necessary, in order that glaciers should descend from the Alps to the Lake of Geneva, and from Snowdon to the low lands between it and the sea,

that those districts should be elevated from 6000 to 8000 feet above their present levels. In higher latitudes the elevation required would be less; but speaking generally, in order that glaciers should descend from the present mountains of Western Europe to the parts that are now near to the sea level, it would be necessary that the whole of that region should be raised into an elevated range from the Polar Circle to the southern margin of the Alps, rising in some parts to a height of 10,000 or 12,000 feet. But such an enormous elevation could hardly take place without leaving great cracks and dislocations in that and the adjoining districts referable to it, while of such dislocations we cannot now find any traces. For this, therefore, and other reasons, its existence seems to be very improbable.

On the hypothesis of the North Atlantic being converted into dry land, although the mean annual temperatures would be lowered very much, yet the extremes of summer heat and winter cold would be greatly increased, and the humidity greatly decreased, which two occurrences, so far as the height of the snow line and production of glaciers are concerned, would counterbalance the lowering of the mean annual temperature. The new continent would be like that of Central Asia, where, although the Altai Mountains are 9000 or 10,000 feet high, and the mean annual temperature is under 32°, yet the glaciers on them, according to M. Tchihatcheff, are of little magnitude or importance.

On this hypothesis, then, in order to get glaciers such as those whose effects have been observed in our mountains, it would still be necessary to elevate them at least 4000 or 5000 feet above their present level.

We now come to the hypothesis which supposes all Western Europe submerged 500 or more feet below its present level, so that the sea should flow all over the low lands, and that the gulf stream should be absent.

In the case of Snowdon we might then have a group of islands, whose tops still reached about 3000 feet above the sea, with a probable mean temperature of 39° or 40°, the height of the line of 32° F. being probably about 2200 feet, or 800 feet below their summit. There would be much humidity and an equable temperature, so that the snow-line might coincide with the line of 32°, and glaciers might descend from it to the level of the sea. If, in addition to these circumstances, we supposed a cold current to set in

from the north, the mean annual temperature might be still further lowered 3° or 4°, principally by lowering the *summer* temperature to the extent of 6° or 8°. This might bring the snow-line down a thousand feet lower, and bring glaciers down to the level of the sea, not only in Snowdon but on the lower mountains of Ireland.

In the Alps, if we suppose a cold northerly current setting down upon their bases, equalizing the climate by lowering the summer temperatures, as the gulf stream does now by raising the winter ones, the mean temperature would be about 45°, and the height of the snow-line would probably coincide with that of 32°, each being about 5000 feet above the sea, and glaciers might descend to the sea level where that penetrated to their bases, and the slope of the mountains was steep enough to admit of a rapid descent of the glaciers. This would suppose the Alps depressed about 2000 or 3000 feet below their present level.

"Thus it would appear from this investigation that the same conditions which would produce glaciers in our Welsh and Irish mountains, descending to the level of the sea from a snow line 1000 to 1500 feet above it, might also produce similar phenomena in the Alps, with a snow-line 5000 or 6000 feet above the sea. In more northerly regions there would, of course, be no difficulty in accounting for the existence of similar glaciers."

Mr. Hopkins then discusses the claims of the before-stated hypotheses on our attention, and gives the preponderance greatly to the latter. As the most probable method of *getting rid* of the gulf stream from the neighbourhood of Western Europe, he supposes that when that was depressed a similar depression took place in North America to the extent of about 2000 feet. The whole plain between the Alleghanies and the Rocky Mountains would then be under water, and the gulf stream, instead of rushing from the Gulf of Mexico through its present narrow outlets by the Bahamas, would run up this central North American sea, carrying a body of warm water in that direction into the Arctic Ocean. This would raise the temperature of the north-western part of America, and the whole north-east of Asia, and would necessarily cause a return current of cold water to flow down to the south, in our portion of the globe. The very same cause, then, which gave to this part of the world the low temperature necessary to produce the phenomena of the glacial sea would give to North-eastern Asia a climate fitted for the support of the herds of mammoths and other huge mammals that for-

merly roamed over the plains of Siberia. This, too, would explain the fact of none of these remains having been found in the plains of North America east of the Rocky Mountains, and would account for the subsequent destruction of all these animals in Asia, on the withdrawal of the gulf stream, consequent on the elevation above the sea of the central plain of North America.

Such is a very brief and necessarily imperfect abstract of Mr. Hopkins's highly important and masterly paper. I will now proceed to examine that portion of his Presidential Address, delivered in 1852, which relates to the kindred subject of—

THE DRIFT.

In discussing the probable cause concerned in the production of those accumulations which we commonly call "Drift," Mr. Hopkins remarks that the moving force of a current estimated by the weight of a block of any assigned form and material, that may be stirred by it, increases as the sixth power of the velocity of the current. In other words, if you double the swiftness of a current, it will move blocks sixty-four times as heavy as before, supposing them to be of the same shape and substance; and if you treble the velocity, it will move blocks 729 times as heavy as before; quadruple it, and its propelling power becomes multiplied by 2048. We are therefore liable to miscalculate the force of a current by reasoning from the ordinary ones that come under our observation.

Mr. Hopkins considers the distinct recognition of the three agencies, glaciers, floating ice, and currents, essential to the establishment of sound theoretical views on this subject. He cautions us, very wisely, not to hold too stoutly to our preconceived opinions on this subject, but to be ready to admit whatever agency may be the *most probable* for any particular case, and not to adhere too strongly to any favourite cause, which may be only a *possible* one.

Mr. Hopkins first examines the striæ and scratches upon rocks. These, he says, when observed in any particular locality, seem to be characterized by the law of parallelism, but when the whole region comes to be examined, they appear to be really divergent. This is the case in Scandinavia, where the striæ radiate from the mountains to the sea, and also in Scotland, where Mr. Hopkins describes them as radiating from several centres. The erratic blocks, whose course Mr. Hopkins next examines, seem to obey a similar law of diver-

gency, following in Scotland along the courses of the principal valleys, as they likewise appear to have done in Scandinavia. We can understand, he remarks, how ice, while travelling down these valleys, should produce locally parallel striæ, radiating from the central mountain mass; but to what cause are we to attribute this prevailing direction being carried out beyond the mouths of the valleys in the open seas? To this question Mr. Hopkins replied by pointing to "waves of translation," caused by sudden and frequent, though not extensive, upward movements of the land.

In North America there appears to be no divergency in the directions of the striæ; but a general parallelism in a N.W. and S.E. direction, the striæ even crossing over the shoulders of mountains in this way, although in the bottoms of the valleys they appear to run parallel to the sides of the valley.

In our own immediate neighbourhood in the county of Wicklow, Mr. Wyley has pointed out to me the vast accumulation of granite boulders at the mouths of some of the principal valleys issuing from the granite hills, and streaming out beyond them over the adjacent country; and any one traversing the county between those hills and the sea must have been struck with the size and frequency of the blocks perched on the tops of the hills, or scattered far and wide over the lower lands.

It is, however, to be remarked, that on their issuing from the valleys, they seem to follow no particular course, and on the west of the hills, towards the county of Kildare, the granite blocks, though not absolutely wanting, are yet much fewer, much smaller, and are confined much more closely to the immediate neighbourhood of the hills, than on their eastern side. These facts would seem to point to icebergs, or to masses of shore ice, acted on by a local current setting to the east, rather than to waves of translation, acting equally in all directions, as the means of transport of these boulders.

Mr. Hopkins next considers the arrangement of materials, and says, that amidst much confusion it appears to come out as a general result that the predominance of finer materials is to be found in the lower part of the drift, and of larger and coarser in the upper. The lower mass frequently consists of fine argillaceous and arenaceous sediment, sometimes mixed with rolled pebbles, the large erratic blocks being superincumbent on this mass, though doubtless sometimes embedded in it. This generalization also coincides with our experience of drift in Ireland.

I may, perhaps, here be allowed to remark, that there is in Ireland a vast field for any geologist who would take up the subject of the drift with a determination to work it thoroughly out. For this object papers giving accurate descriptions of observed facts in particular localities would be of the greatest use; I therefore hailed with great satisfaction the letters we received from Mr. Stanley, giving us some observations on the drift of the neighbourhood of Tullamore.

Although we might not be prepared to accept all the conclusions stated in Mr. Stanley's letters, it must still be a gratification to us to find any earnest and enthusiastic man endeavouring to work out for himself the phenomena of his own district, since we know that any one who thus works patiently and perseveringly, with the single desire of arriving at the truth, will ultimately reach it, and will be rendering the greatest service to our science by the extension of observed and recorded facts.

The letter from the Rev. A. B. Rowan, of Belmont, Tralee, describing a limestone boulder on the side of a hill 600 feet above the present level of the limestone of the neighbourhood, though speaking of a fact sufficiently familiar to us all, gives us a satisfactory indication of the existence of another good observer, who would render us good service if he would only extend and record his observations.

My friend and colleague, Professor Ramsay, published, during 1852, his paper on the "Sequence of Events during the Glacial Epoch, as evinced by the superficial accumulations of North Wales." In this paper the author describes the polishing and striation of the rocks *beneath* the drift accumulation, and also the moraines caused by glaciers subsequent to the deposit of the drift, which glaciers had in one instance scooped a great channel in the drift, clearing it entirely away from one side of a valley. He also showed that the accumulation of blocks and *debris* on the seaward flanks of the Caernarvonshire Mountains were part of a connected deposition of drift, which stretched continuously along them, reaching sometimes to the height of 2000 or 2300 feet above the sea, proving a depression of the land to have once taken place, to at least that amount below its present level. Professor Ramsay attributes these phenomena to, first, a great elevation of the land, causing the first great glaciers, which produced the polishing and striation, then a depression beneath the sea in which the drift was accumulated; and lastly, a

re-elevation producing another glacier period. Mr. Hopkins does not agree with Professor Ramsay in his first great elevation, since he shows, in the paper I have just described to you, that glaciers might have been formed on Snowdon by the abstraction of the gulf stream, and the bringing in of a cold current from the north, but in the subsequent sequence of events there would, I believe, be no great difference of opinion between them.

It appears to me indeed that Professor Ramsay's succession of events singularly harmonizes with Mr. W. Hopkins' theoretical views. The first great glaciers might be the consequence of the first abstraction of the gulf stream and setting in of the cold northern current; the land might then be gradually depressed till it was lowered 2300 feet below its present level, and thus get too low for the formation of glaciers, though its shores might still be incumbered by winter ice; it might then have been gradually elevated again till its summits became re-covered by perpetual snow, and glaciers again formed, which would in some cases plough channels in the incohærent drift. Many similar oscillations of level, and changes in local conditions, might have taken place within the glacial period, caused by the reversal of the oceanic currents.

As an interesting paper in connexion with such part of the drift as can have been produced by great currents, I wish to direct your attention to Mr. Prestwich's account of the "Effects of the Holmfrith Flood," describing the circumstances under which it occurred, and the power it exerted in the transport of heavy materials. Any one who would send to us a similarly accurate and detailed account of the effects of the floods in the rivers Lee and Blackwater, and in other parts of the south-west of Ireland during the last autumn, would be doing good service to our science.

I may here also notice that in Professor Nicoll's Paper on the "Geology of Cantyre, Argyleshire," he describes the drift of that peninsula, and also an interesting example of the raised beach, about 30 feet above the present level of the sea, so well known on the west coast of Scotland. In one part of Cantyre is a long ledge at this height, beneath a precipitous cliff of very hard porphyry, in which is a line of caverns, stretching in even 130 feet into the rock, their floor covered by boulders and shingle, by whose agency the former breakers excavated the caverns. Professor Nicoll remarks on the long period of time during which the land must have been stationary

at that level, for the erosive action of the sea to have produced such an effect on so unyielding a material, and that the period must greatly have exceeded that which has elapsed since the elevation of the land to its present level.

Space will not allow me to do more than direct your attention to Dr. P. C. Sutherland's Notes on the "Geological and Glacial Phenomena of the coasts of Davis's Straits and Baffin's Bay," where an action is now going on through the agency of shore-ice, glaciers, and icebergs, such as we believe to have occurred in our own regions during the existence of the glacial sea. One fact mentioned by him is very remarkable, namely, that while the glaciers are of great size on the coasts of Greenland and Davis's Straits, where the rocks are crystalline, they are comparatively few and unimportant on the upper Silurian tracts in the neighbourhood of Prince Regent's inlet. It appears that although the mean annual temperature is lower in the latter than the former, yet the summer heat is greater, and is therefore sufficient to melt the winter's snow and ice, and cause it to run off in water instead of accumulating into glaciers.

I would also recommend to your notice the Paper by Mr. Morris on some railway "Sections in Lincolnshire," where he gives some very curious details of the "drift" of that locality.

Mr. Trimmer's Papers on the "Erratic Tertiaries," and on the "Gravels of Kent," form part of a series of very elaborate investigations, entering into much minute detail from which we may ultimately derive results of great value, but of which it would be impossible for me to give you even an abstract with the space at my disposal.

One circumstance which occurs in nearly all these descriptions of English drift, as particularly in one by the Rev. H. M. De la Condamine on that of Huntingdonshire, is the occurrence in it of freshwater beds with freshwater and land shells.

This is a part of the drift subject which more especially requires working out in Ireland; and from devotion to which there is little doubt that good results would arise if any of our more active members would take it up.

I have been led insensibly by the discussion of Mr. Hopkins's paper to enter more largely on the subject of "Drift," than I at first intended. I will close it by one observation, namely, that we in Western Europe are in danger of being insensibly biassed by the

very prominent action of the conditions of the glacial sea, to attribute to them more than is justly their due. We must recollect that "Drift," meaning by that term superficial accumulations of clay, sand, and gravel, often of great thickness and extent, and composed of fragments of respectable weight and dimensions, is not confined to the region of the glacial sea of Western Europe, but occurs in almost all countries, in nearly all latitudes. I have only to remind you of the thick auriferous deposits of Australia, where beds of consolidated gravel interstratified with sand and clay, 60 or 70, or even, if recent accounts are true, as much as 150 feet thick at least, occur over very large tracts, containing great blocks of quartz, weighted with gold up to more than a hundred-weight, to show that glacial conditions are not absolutely necessary for the transport of very considerable masses, some distance from their parent site.

In the Journal of the Geological Society of London for May, 1853, there is a very good descriptive paper on the gold-fields of Victoria or Port Philip, by Mr. G. H. Wathen, Mining Engineer. He gives a general description of the structural features of the country, as well as of the auriferous drift. In speaking of the latter, he mentions boulders of quartz, two or three feet in diameter, as embedded in the "pipe-clay."

My friend and former colleague, Mr. Alfred R. C. Selwyn, now Director of the Geological Survey of Victoria, writes me word that he has at present reason to believe that this auriferous drift of Australia is of older date than the volcanic deposits of heavy hornblendic or augitic lava or trap, that form such conspicuous features in the geology of Victoria. He says that he has never seen a pebble of those traps or lavas, in the drift of that country, and never observed any of the drift resting on the lava; while he has reason to believe in some instances that the lava rests upon the drift. The clearing up of this point will be one of the many interesting results we may expect from that gentleman's survey of the colony.*

Having been led to commence with the subject of drift, I will

* Since the above was written, I have had the advantage of perusing Dr. Hooker's most interesting Travels in the Himalayahs, and have, among other things, been greatly struck with the proofs he there gives us of a former much greater intensity of glacial action, even there also, than exists at the present day. Although it may not be impossible to imagine changes in the configuration of land and sea sufficient

throw the remainder of my observations into geological sequence, commencing with

THE TERTIARY ROCKS.

There is a paper of local interest in the London Geological Journal for 1852, by J. Brown, Esq., on the "Upper Tertiaries at Copford, Essex," chiefly descriptive of some beds of brick earth, apparently lying above the drift, and containing bones of bears and beavers, with land and fresh-water mollusca, of which two are of extinct species.

In the same volume we have a very elaborate and critical paper by Sir C. Lyell, on the "Tertiary Strata of Belgium and French Flanders." This paper is full of minute detail, with descriptions of the structure of many localities, and complete tables of fossils, and other valuable matter, making it a great paper for future reference, but not allowing of the process of condensation or abstraction. It is an account of the whole tertiary series of the countries named, and an identification of their several portions with the contemporaneous strata of England.

We have likewise a paper on the "Thanet Sands," or the bottom bed of the English eocene tertiaries, which forms part of a very elaborate and long-continued investigation by Mr. Prestwich into the exact structure and relations of the lower eocene rocks of Britain. The series of papers of which this forms a part is of the greatest value, the result of great labour extended through many years in such intervals of business as may occur in the life of a London merchant, and shows us how much may be done by steady perseverance and determination, even where circumstances seem most adverse to it.

In the Geological Journal for 1853, we have first a paper by J. Motley, Esq., on the Geology of Labuan, more especially descriptive of the coal formation there, which is evidently altogether of tertiary age. He gives a section of about 300 feet thick of alternations of clay or shale and sandstone, with several small seams of

to account for this, yet it is not easy to see why these changes should always have been such as to produce *greater cold* at a particular period of the earth's history, and that over a space so widely separated and so differently placed as Western Europe and Southern Asia. Such phenomena seem certainly rather in favour of the hypothesis of a general lowering of the temperature of the whole globe at this period.

coal, and one having a thickness of 11 feet. This coal is composed of slightly compressed trunks of trees crossing each other at all angles; these trunks are of dicotyledonous wood, and very similar to the trees now growing on the island, with lumps of resin of exactly similar character to that which they produce. In one bed of blue clay, stems of dicotyledonous trees, and occasionally of palms, are found upright and silicified. Large boulders of coal often occur, sometimes in regular layers, and some coarse conglomerates of quartz, sandstones, and coal pebbles. In some of the clays are marine fossils of such existing genera as Tridacna, Tellina, Murex, Pyrula, Oliva, Cerithium, Fusus, as well as others. The beds are inclined at angles varying from 25° to 70°, and similar beds near Bruni are absolutely perpendicular.

I must also call your attention to a very interesting paper by Major Vicary, of Wexford, on the structure of a portion of the "Himalayah range near Subathoo." It must be highly satisfactory to us to see so many officers of the army and navy making use of their opportunities to contribute to the advancement of our science, and by their observations, often hastily made in the intervals between sterner duties, thus enabling us to link together scattered information, and harmonize our knowledge of these distant regions.

The more detailed information we may hope ultimately to receive from my distinguished predecessor on the Survey, and your former President, Professor Oldham, will thus be capable of extension over a much wider district than he will probably be able to visit either personally or by means of his two able assistants, Messrs. J. G. and H. B. Medlicott, both members of this Society.

Of other Indian papers I have only space to mention the titles, as follows:—

Dr. Fleming on the Salt Range of the Punjaub.

Dr. A. Fleming on the Geology of part of the Sooliman Range.

Mr. H. B. E. Frere on the Geology of a part of Sind.

Dr. F. L. Bell's further Account of the Boring at Rotah, Deccan; and a Notice of an Ichthyolite from that place.

The above remarks will likewise apply to Colonel Heneken's paper on the "Tertiary Deposits in San Domingo." From this paper, and the abundant collection of fossils that accompanied it, it appears that that island is largely composed of tertiary rocks of eocene age, presenting the nearest analogies, as a group, to those of

Malta and Bourdeaux in Europe, and South Carolina in America; and that of the 8 or 9 per cent. of living forms that they contain, the majority are living in the adjoining seas; while many have a strong resemblance to, and one or two are identical with, shells now living in the Indian and Pacific Oceans. They thus seem to point to a time when the connecting land between North and South America did not exist, or was to have been found to the east of its present situation. We are almost tempted to ask, can the present curved line of the West India Islands have any relation to the line of some ancient coast, and the Carribbean Sea have been in those days a bay of the Pacific instead of one of the Atlantic, as it is now?

The most important and interesting paper, however, on tertiary rocks, published during the year 1853, is that by my friend and colleague, Professor Edward Forbes, now President of the Geological Society of London. We may be allowed, perhaps, to claim it as one of the advantages of a Goverment Geological Survey, in a scientific point of view, that, as we examine all districts indifferently in an equally detailed manner, we now and then are likely to come upon new facts in places, the structure of which has hitherto been taken for granted as sufficiently known, and therefore not critically examined. When Professor Forbes came, in the course of his duties on the Survey, to examine the fossil localities of the northern part of the Isle of Wight, he found so much that was not only palæontologically but geologically new, that he was obliged, even with the able assistance of several other officers of the Survey, to devote four months of constant and daily labour to its examination.

You are aware that it had been hitherto supposed that, while the lower and middle portions of the eocene system were fully represented in England, there was a total absence of all the upper portion of that series. The highest English eocene beds were believed to be only on a parallel with the upper part of the *calcaire grossier* of the Paris basin, and we were supposed to have no equivalents of the well-known gypsum beds of Montmartre, or the lower freshwater limestone and its superincumbent beds. The new researches of Professor Forbes prove that we have in the northern part of the Isle of Wight the exact palæontological equivalents, with well-marked lithological characters, of even the highest beds of the Paris basin, and of beds that are probably even higher than any there ; namely, the Rupelian, or Upper Limburg beds of Belgium.

Professor Forbes shows that those beds which have been hitherto lumped together as Headon beds are capable of a threefold subdivision, into what he terms, the Saint Helens' beds as the lowest,—the Bembridge series as the middle,—and the Hempstead series as the highest. The two latter are themselves again capable each of a threefold or fourfold division into "stages," characterized by peculiar fossils. Characteristic fossils of these groups are now deposited in the British tertiary cases in the palæontological galleries of the Museum of Irish Industry, where they are open to your inspection and study.

This discovery is very important, first as showing that Great Britain has the most complete series known of the eocene tertiaries, as she has of the secondary rocks, and has them in immediate connexion and direct order of superposition; and secondly, as giving us a key to the classification of large districts of the Continent, where widely-spread and important beds must now be referred for their nomenclature to a few little spots in the northern part of the Isle of Wight. It will indeed introduce important changes in the colouring of the Geological Map of Europe.

SECONDARY ROCKS.

Although there are several papers in the two last volumes of the London Geological Journal on minor and local points in secondary geology, doing great credit to their authors, and contributing facts highly worthy to be known to the great body of geological science, there are none of sufficient general interest, or at least of sufficient interest to us in this country, to warrant me in taking up your time by giving any account of them.

In our own Journal the only paper on secondary geology is one by J. B. Doyle, Esq., entitled, "Notes on the Salt Mines at Duncrue, and Searches for Coal by the Marquess of Downshire." The details of the sinkings given in this paper are valuable as records, and the section gives a good general idea of the structure of the neighbouring district. There is, however, no mention made of the lias, a thin band of which I observed when examining this district in company with the Marquess of Downshire in 1852, just at the top of the red marl. The conformability of the beds mentioned by Mr. Doyle of course gives us no assurance of the same structure continuing below the beds examined, and the place where unconforma-

bility is most to be dreaded is at the base of the new red sandstone series, which is as likely to rest upon any of the inferior rocks as upon a productive portion of the coal-measures.

PRIMARY OR PALÆOZOIC ROCKS.

Of this portion of the geological series we have several papers, of great interest and importance, in the Geological Journals for 1852 and 1853. In the first place, we have three papers by my beloved old master and geological father, Professor Sedgwick, on the palæozoic rocks of Devon, North Wales, and Cumberland, giving additional descriptions of the structure of those countries, in his usual graphic and masterly style. He has, however, another paper of still higher importance, as bearing more directly on the general classification of the palæozoic rocks, namely, the one "On the proposed Separation of the so-called Caradoc Sandstone into two distinct Groups, viz.:—1. May-Hill Sandstone; 2. Caradoc Sandstone." Professor Sedgwick proves, what had also been recognised by the Geological Survey, that under the name of Caradoc sandstone two distinct sets of beds have been confounded. This has happened from the fact of two sandstones coming together of somewhat similar mineral character, although containing distinct fossils. In consequence of their similarity in mineral character, and their reposing directly one on the other, the fossils had been mingled together,* and thus quoted as from one group, while in fact those from the upper beds were different from those in the lower; the first belonging to the Wenlock type, and being therefore upper Silurian; and the latter having much more of the Bala aspect, and belonging, therefore, to the lower Silurian. Even in the true typical Caradoc country in Shropshire, these two sandstones have been subsequently separated by the Survey, inasmuch as not only were their fossils distinct, but the upper group was found to repose unconformably on the lower.† Professor Sedgwick justly points out that this separation which he introduces between rocks that had hitherto been confounded un-

* It was this mingling of character which led me, in a little work called "Popular Physical Geology," published last year, to speak of the Caradoc sandstone as "middle Silurian."

† See the paper by J. W. Salter and W. P. Aveline, "On the Caradoc Sandstone of Shropshire," in the first part of the London Geological Journal for 1854, which has appeared since this was written.

der one name likewise introduces a sharper and more distinct line of boundary between those two great formations which have been hitherto known as upper and lower Silurian, but which he would now call Silurian and Cambrian. I think it very likely that he is right in another point also, namely, that the Merioneth and Denbighshire Caradoc of the Geological Survey Maps belongs rather to the base of the Wenlock than to the true Caradoc sandstone; that it is a local thickening of the sandy beds of the lower part of the Wenlock shale as they approach the trappean hills on the west. I also think it probable that the true Caradoc sandstone is only a similar local thickening and passage into sandstone of the upper portion of the Bala beds as they travel towards the east. There is, however, distinctly no unconformity—except, perhaps, in one very small locality—in the position of the beds of the upper and lower Silurian formations in North Wales; as the upper Silurian—whether called Caradoc sandstone or Wenlock shale—rests on the same thin group of "*pale slates*," forming the top of the Bala beds from Mallwyd to Conway in one direction, and to Llangollen and Bwlch Rhiw Felyn in the other.*

I will just here say one word as to the controversy respecting the terms "lower Silurian" and "Cambrian." It resolves itself into a question of whether we should take palæontological or lithological and stratigraphical characters as the foundation of our classification. Every one—including Professor Sedgwick and Sir Roderick Murchison—used to think that the rocks and fossils of Caernarvonshire and the neighbouring parts of North Wales would of necessity be all older than those of Montgomeryshire, Shropshire, and the Welsh border country. The Silurian rocks and fossils, therefore, with their subdivision into upper and lower, were *accepted* as one thing; and the Cambrian rocks and fossils were *expected to turn out* another thing when the latter came to be fully

* It seems pretty clear, then, that the term "Caradoc sandstone," as designating an independent formation, having peculiar lithological and palæontological characters, must disappear. Whether the term should be applied to the sandy beds at the base of the Wenlock shale, or to the similar sandy beds at the top of the Llandeilo and Bala formation, remains to be decided. I should myself prefer to keep the term as representing a local group at the top of the lower Silurian, and to adopt Professor Sedgwick's name of "May-Hill sandstone" or "Wenlock grits" for the base of the upper Silurian.

described. Instead of that, it results that what were called the lower Silurian rocks on the Welsh border, and which were left with a totally undefined base, had really a much greater thickness than was expected, and swept in many broad folds and undulations through the whole of North Wales; and that the rocks of Siluria, with the exception of the uppermost, were the same as those of Cambria. In Cambria, however, the rocks only were described, while in Siluria both the rocks and fossils were described and figured; neither, indeed, completely, but both so much so that the contemporaneous rocks of other countries could be recognised by their fossil characteristics. Had the identity of the rocks of Cambria and Siluria been known at the time, it is probable that only the upper would have been called Silurian, and the lower would have been christened Cambrian. It was not so known or understood, however, and it has now, I believe, become practically impossible to remedy the mistake, if it be one, and to persuade men to call those things Cambrian which they have always been in the habit of calling Silurian, although no one will be more ready than myself to adopt the change of nomenclature, should it be generally decided on. The only way to bring such a correction into use would be to adopt a middle term, and to speak of the lower Silurian as Cambro-Silurian.

I would here remark, also, that the conformity which appears in North Wales between these Cambro or lower Silurian rocks and those below them, and which enables them, therefore, to be grouped as upper and lower Cambrian, has been now, as you are aware, shown not to exist in this country. The paper submitted to you by Mr. Wyley and myself proves an utter discordance and the widest unconformability possible, between the great lower Silurian formation of black slate and that equally large mass of green and red slates and grits of the county of Wicklow, which, by every lithological evidence is identical with the Barmouth and Harlech, or the Llanberris and Penrhyn group of North Wales, to which the term Cambrian has been applied by the Survey. If that identity be admitted, it is scarcely possible to include under the same name the upper and lower rock groups of Caernarvonshire and Merionethshire. It is clearly impossible to do so in Wicklow; I am, therefore, on the whole, for the sake of convenience alone, inclined to retain the name of lower Silurian, however otherwise inappropriate it might be

shown to be, and to restrict the term Cambrian to these lower group of rocks in North Wales, Ireland, and the Lake District; and I say this reluctantly, and in spite of my natural feeling, which would lead me to back the opinions of Professor Sedgwick against all the rest of the geological world.*

The paper to which I have just alluded contains two principal points:—1st. That the so-called lower Silurian rocks repose quite unconformably on the edges of the beds of a very low portion of the Cambrian series. 2ndly. That no portion of the Cambrian series is seen anywhere to repose directly on the flanks of the granite hills, the granite having come up through the Silurian rocks, which, for a certain space, *dip towards the granite*, having merely the edges of their beds turned up against it, directly on the flanks of the granite hills.

The paper likewise gave a sketch of the general relations of the quartz rocks to the slate beds; a subject which has been treated of more largely by Mr. Kelly, in his paper "On the Quartz Rocks of the northern part of the County of Wicklow." Mr. Kelly's paper is a valuable and interesting one, as must every paper be that is the result of fair, honest, hard work and observation in the field. I believe, however, that its value is deteriorated by many of the observations having been made after the hypothesis was formed which they are held to support. If I am wrong in this, I hope Mr. Kelly will pardon me; but I believe that in some of his sketches and diagrams representing particular localities, the actual data observed have been connected and extended in such a way as to support the hypothesis, when they might with equal propriety have been so drawn as to give a different interpretation to the facts. I allude more particularly to the maps where the quartz rocks have been connected and extended over spaces where no rock can be seen, and where slate may exist with equal probability; and to the diagrams on pp. 249, 251, and 252, where the lines marking the bedding of the slate are, I believe, not strictly accurate, or, perhaps, represent partly bedding and partly cleavage lines. In the diagram

* If we do away with the term lower Silurian, and replace it by Cambrian, it will be necessary to invent some other term to designate the green and red grits and slates of Caernarvon and Merioneth, on one side of the Channel, and Wicklow and Wexford on the other, which in each country are the lowest visible stratified rocks.

on p. 249, the non-extension of the two little slate beds into the quartz rock is obviously quite a gratuitous supposition, and therefore the extension and connexion of the mass of the quartz rock below is equally hypothetical.

In two other diagrams, as that on p. 250, the abutting of the slate rocks against the quartz rocks is, I believe, produced by small faults. In the large diagram on p. 255, I have little doubt of the features of the quartz rock being quite correct, and think that only a little irregularity is requisite to be introduced into the slate beds to make it a true picture of nature, and one of which many examples might be found among irregularly bedded and contorted rocks of all descriptions.

Mr. Kelly's hypothesis is, "that the great masses of quartz rock now brought in this locality to the surface were once joined to and formed part of a regular system of stratified quartz rock lying below the gray slaty rocks; that they were in this position rendered semifluid or plastic by subterranean heat, and protruded through enormous fissures made in the overlying grewacke by volcanic or other expansive power from below." After an attentive examination of the district, Mr. Wyley and I came to the conclusion that there was nothing in the structure of the country inconsistent with the received opinion of the quartz rocks here, as elsewhere, being altered sandstone (whether baked or steam-boiled), deposited originally in very irregular beds, often suddenly thickening or thinning out, and ending sometimes very abruptly, interstratified with shales or slates and other sandstones still unaltered, the whole having been subsequently disturbed and enormously contorted, perhaps by successive actions of disturbance at different periods. These disturbances seem sometimes to have almost twisted the beds into "true lovers' knots," or other fantastic devices; and as these contorted beds have likewise been broken through by faults and very irregularly denuded, and are now often very imperfectly shown, they must necessarily, in some places, be very mysterious and unintelligible in their appearances.

While on the subject of quartz rock, I would particularly call your attention to a paper by Mr. D. Sharpe, in the eighth volume of the Geological Journal, on the quartz rocks of Scotland. He shows a very large portion of the quartz rocks of that country, which are interstratified with beds of limestone and thin beds of

schist, to be really integral portions of the old red sandstone. This paper is followed by another interesting paper by the same author, on the "Southern Borders of the Highlands." Mr. Sharpe has recently been engaged, at the request of the Geological Society of London, in correcting and revising M'Culloch's Geological Map of Scotland, and has produced and presented to that Society what is, I believe, quite the nearest approximation to an accurate map of that country which we possess.

In the Philosophical Transactions for 1852 is a paper by Mr. D. Sharpe, "On the Arrangement of the Foliation and Cleavage of the Rocks of the North of Scotland." In this paper the author first connects the phenomena of cleavage and foliation, and looks on them as passing into each other, and then describes those of the Highlands of Scotland as parts of planes forming a series of great arches, often of many miles in radius; the cleavage or foliation planes being perpendicular at what may be called the piers or abutments, and bending over at the crowns of the arches.

The paper, like all Mr. Sharpe's productions, is characterized by great ingenuity and clearness of statement; but whether its conclusions are based on a sufficient number of accurate observations still remains a doubt upon my mind. Perhaps no country is more thoroughly "cleaved" than the south of Ireland, where every formation up to the mountain limestone, and I believe the coal-measures, is affected by it. So far as I have at present observed, the phenomena of cleavage here lend no support to Mr. Sharpe's views. From Bray Head to Bantry Bay the cleavage strikes in one general direction, varying only from E. and W. to E. 25° N. and W. 25° S. It almost constantly approaches so closely to a vertical position that the deviation is within the errors of observation, or the amounts of its own local variation; but when it does decidedly incline from the vertical, I believe that inclination is almost invariably to the north, never at a less angle than 60°. More extended observations on this point, however, are yet needed.

The Duke of Argyle has a paper in the ninth volume of the Geological Journal, which is of great general interest, and to me peculiarly so, as tending to confirm ideas long loosely floating in my mind, and which this last summer acquired more precision from my examination of the county of Wicklow. The general notion, I think, with respect to the action of granite is, that it is the grand

disturbing and elevating agent forming the axis of mountain chains, having the lowest of their rocks reposing on its flanks, with successively higher rocks dipping on each side from that central axis. I by no means intend to deny that this structure does occur, though I have myself never seen an instance of it, but I have long had great doubts of its being a necessary, or even a general, occurrence. I have never felt any inclination to attribute any *elevation* or *disturbance* of beds to the intrusive action of any igneous rock, from granite down to lava; on the contrary, I have always been more inclined to look on the outburst of any igneous rock as giving local relief to the intensity of the disturbing force, and as, therefore, mitigating and diminishing the amount of disturbance in the neighbourhood of it. Of course I do not speak of any minor crumpling or dog-earing of the ends of the beds in actual contact with the igneous rock.

The Duke of Argyle, in his paper on the " Granite District of Inverary," describes the great gneiss and mica schist formation of Argyleshire as bent into a broad anticlinal arch between the valleys of the Clyde and Loch Fyne, the beds dipping S. E. and N. W. towards these valleys respectively. In the centre of this anticlinal arch, and along the line of the axis of elevation, there is no appearance of any outburst of granite or other igneous rock, while on the north-western side of the district, between the valleys of Loch Awe and Loch Fyne, where the rocks all dip steadily to the N. W., are great outbursts of granite. The Duke of Argyle describes these as apparently interstratified with the mica schists. Not being acquainted with the country, I can offer no opinion on that point, or how far the facts of the case bear out his Grace's hypothesis of the mica schist at the period of disturbance having " fallen in," as he expresses it, and huge sheets of granite being then injected between the beds, so as to produce the appearance of interstratification. I would, however, just point out to you the analogy between the above facts and those which I described as existing in the structure of the county of Wicklow. There the granite range, although of great size and extent compared with the stratified rocks, and though clearly subsequent to them, as shown by the alteration it has produced on them, and the abundance of veins it sends into them, yet is not the geological axis of the district; on the contrary, the main areas of elevation, as shown by the occurrence at the sur-

face of the lowest rocks, are removed from the granite, which cuts up through the higher rocks, and moreover traverses them obliquely to all appearance, so as to cut different beds in one part from what it does at another. Moreover, along a band of country a little removed from the granite the beds plunge headlong towards it, on each side of it; a fact which suggested to me the idea of their having " fallen into a cavity" left void, as it were, by the intrusion of the granite upwards, though there is no appearance of any injection of granite along the line of this " falling in."*

Before leaving Scotland I will briefly call your attention to a very excellent paper, by Professor Nicoll (formerly of Cork, now of Aberdeen), on the " Geology of the Southern Portion of the Peninsula of Cantyre," which I have already had occasion to allude to when speaking of drift. He corrects M'Culloch's map of the palæozoic and igneous rocks of that district. There are also two sound descriptive papers on the Silurian rocks of the south of Scotland, by Professor Harkness, now of Queen's College, Cork, which give us much valuable and wanted information.

You will hardly need any indication from me of the great interest atached to Mr. Logan's paper on the foot-tracks in the Postdam sandstone in the neighbourhood of Montreal, in Canada, and of Professor Owen's discussion of the nature of the animal that caused them. The Potsdam sandstone is, as you are aware, at the base of the Silurian formation of North America, corresponding in age nearly with the oldest of the *black slates* of the county of Wicklow. It was at first thought that the foot-tracks were caused by animals of the reptilian or batrachian class; a fact, had it been warranted, calculated to have excited great interest. Professor Owen, however, by one of those close, detailed, and exhaustive processes of reasoning from minute indications, and by that application of his vast and profound knowledge to render luminous facts apparently obscure, which have deservedly procured for him the name of the English Cuvier, has shown that the animal that made these tracks was a crustacean, and he points to the present limulus, or kingcrab, as its most probable analogue.

* It will of course be understood that I keep in mind the undoubted fact of all these operations having taken place under a vast thickness of Silurian rock which is now denuded. But for this covering the granite could never have cooled as granite.

Dr. Bigsby has two papers on the geology of portions of Canada: one on the neighbourhood of Quebec, the other on the more remote district of the Lake of the Woods. Both contain valuable contributions to our geological knowledge.

Space will not allow me to do more than give you the titles of several other papers on palæontological points connected with the lower palæozoic rocks. These are:—

1. By my late lamented friend, Mr. Hugh E. Strickland, one of the martyrs of our science,—"On the Distribution and Organic Contents of the Ludlow Bone-Bed in the Districts of Woolhope and May-Hill; with a Note by Dr. Hooker on the Seed-like Bodies found in it."

2. By Professor M'Coy, of Belfast,—"On the supposed Fish Remains, figured on Plate 4 of the Silurian System."

3. By Sir R. I. Murchison,—"On some of the Remains in the Upper Ludlow Rock."

4. By Senhor Carlos Ribeiro,—"On the Carboniferous and Silurian Formations in the neighbourhood of Busaco, in Portugal; with Notes, and a Description of the Animal Remains, by Mr. D. Sharpe, Mr. J. W. Salter, and Mr. T. Rupert Jones; and an Account of the Vegetable Remains, by Mr. C. J. F. Bunbury."

5. By Mr. J. W. Salter,—"On Arctic Silurian Fossils."

I must, however, before quitting the Silurian rocks, commend to your attention the very careful paper, printed in the last Part of our Journal, by Mr. H. B. Medlicott, on the Geology of Portraine, county of Dublin. In this paper as good a description is given of the structure of the district as could well be formed from the scanty materials to be found in it. I should be glad to see some of our junior members contributing similar papers to our meetings.

We have several instructive papers on the structure of the upper palæozoic rocks, some of which have been brought before ourselves, some before the Geological Society of London.

The point on which we have still the greatest difficulty is on the rocks which form the connecting link between the upper Silurian and lower carboniferous rocks; in other words, on the Devonian series. The old red sandstone is for the most part the monument of a destructive rather than of a productive action. It shows great forces of denudation and erosion to have been at work on the previously existing rocks, and is itself, therefore, little to be

trusted for a history of the succession of organic life, or of the gradual production of earthy matter under conditions of tranquillity. Wherever such rocks occur they are the indications of a great break and of an immense lapse of time, during which regularly deposited rocks, with regular series of organic remains, must have been in course of formation somewhere.

In order to carry on our geological history properly, we ought to throw aside the first, and attend solely, or nearly so, to the evidences afforded by the latter, when we can discover them. For this reason, every attempt to put into proper co-ordination the series of Devonian rocks is deserving of our careful attention, and among these I would place in the foremost rank a paper by Mr. Daniel Sharpe, entitled, " A Review of the Classification of the Palæozoic Formations adopted by M. Dumont for the Geological Map of Belgium."

M. Dumont throws the whole of the palæozoic rocks of Belgium —from the coal-measures down to the upper Silurian, inclusive— into two great groups, which he calls Terrain Anthraxifere and Terrain Rhenane. Each of these two " terrains" are divided into three " systems," as in the following Table:—

Terrain Anthraxifere.	Coal measure system,		1. Sandstones, shales, and coal.
	Condrusian system,	Calcareous,	2. Crinoidal limestone, dolomite, limestone with productus, chert, and anthracite.
		Arenaceo-schistose,	3. Sandstones with anthracite. 4. Gray shale, calcareous shale, limestone, and oolitic " oligiste."
	Eifelian system,	Calcareous,	5. Limestone and dolomite.
		Arenaceo-schistose,	6. Gray fossiliferous shale, calcareous shale, and argillaceous limestone, oolitic "oligiste." 7. Red conglomerate, sandstone, and shale.
Terrain Rhenane.	Ahrian system,		8. Bluish-gray grits, sandstones, and shales.
	Coblentzian system,		9. Bluish-gray grits and flags.
	Gedinnian system,		10. Greenish-gray conglomerates, and red and green flags.

Mr. Sharpe dissects and readjusts this classification, co-ordinating it with our British classification, and putting it into English nomenclature, as follows:—

Belgian.	Lithological Description.	English.	
Coal-measure system, ...	1. Sandstone, shale, and coal,	Coal-measures.	
Condrusian system,	2. Crinoidal limestone, &c. . .	Upper carboniferous limestone.	
	3. Sandstone with anthracite, .	Carboniferous sandstone of N. of England.	Carboniferous series.
	4. Gray shale, limestone, &c.,	Lower carboniferous limestone; lower limestone shale of Northumberland and Scotland; culm measures of Devonshire, including Petherwin and Pilton beds.	
Eifelian system, . .	5. Limestone of Eifel, ...	Limestone of South Devon.	Devonian series.
	6. Gray fossiliferous shale, &c.,	Shales and schists below ditto.	
	7. Red conglomerate, &c., . .	Old red sandstone.	
Ahrian system, . .	8. Bluish-gray grits, sandstones, and shales, . . .	Ilfracombe and Linton series and sandstones S. of Plymouth.	Old red or Rhenane series.
Coblentzian system,	9. Bluish-gray grits and flags.	To be sought for in south of Cornwall.	
Gedinnian system, .	10. Greenish-gray conglomerates and red and green flags, .	Tilestones of Upper Ludlow.	Silurian.

On this classification of Mr. Sharpe's I should wish to say a few words. First of all, I do not know on what accurately ascertained grounds he separates the carboniferous limestone of the north of England into an upper and a lower, with an intermediate group of coal-bearing sandstones, between them. My own belief is, that the upper portion of the mountain limestone of Derbyshire becomes split up towards the north by beds of shale and sandstone, the limestone gradually dying out and beds of coal coming in, and that this gradual change of type is continued deeper and deeper into the formation the farther we go north, until eventually, in Scotland, the carboniferous system consists throughout of coal-measures, with some comparatively unimportant beds of limestone (only two, of 20 or 30 feet each, near Edinburgh), and that these coal-measures at the base of the system, resting directly on the old red sandstone, are the representatives of the mountain limestone, and not of the

coal-measures, of south and central England. I believe, also, that it will ultimately be found that a similar change in the lithological character of the carboniferous series takes place in Ireland; that, for instance, the Ballycastle coal-field is low down *in* the mountain limestone, and perhaps at the bottom of it; in corroboration of which idea Mr. Ormerod, of Manchester, informs me that in the upper part of that small coal-field he observed, not long ago, a band of limestone full of Productæ. With such great changes of type within our own islands, therefore, any minute identification of parts of the Belgian with parts of our own series becomes to the last degree rash and dangerous.

If, however, Mr. Sharpe wished to identify Group 4 with any portion of the carboniferous rock of Britain, it appears to me much more natural and much more safe to go to South Wales instead of to Scotland, and to point to the lower limestone shale, which there underlies the solid carboniferous limestone, as its probable equivalent. He might then carry on those beds into Devonshire, and place them on the horizon of the beds of Pilton and Barnstable, in the north, and of Tintagel and South Petherwin in the south. As to the culm measures of Devon, I should myself be more inclined to look upon them as the equivalents of the culm measures of the south of Ireland, which repose directly on the mountain limestone, and therefore to suppose a gap between those of Devon and the Pilton beds.

I wish, however, to speak with great hesitation as to any portion of Devon, as my knowledge of it is confined to that gained during a visit of a few days only, in company with Professor Sedgwich, in 1841.

Mr. Sharpe identifies Group 7 (the red conglomerate) with our old red sandstone, considering it its entire equivalent; while the two groups just below (8 and 9) are full of Devonian fossils, such as those found in the Eifel limestones above. Any argument drawn merely from variations in thickness in the two parts of the formation would have little weight with me. The old red sandstone of parts of Wexford is not more than 20 or 30 feet thick, while in the western parts of Waterford it is more than 3000.

I think, however, it would be prudent to wait for a little more evidence before considering this identification established. Mr. Sharpe seems to feel a difficulty in supposing that in the same sea two de-

posits were forming at a short distance apart: the one, of red sandstones and conglomerate; the other, of gray schists and limestones; without any interchange of characters between them, or any gradual passage from one into the other. To this we might reply, that as the beds are not continuous, on account of the intervention of the Bristol Channel, there may have been passage beds which are now removed or concealed. Any one who will examine the great beds of red sandstone and conglomerate of the county of Waterford, capped by thick yellow sandstone, on which the mountain limestone rests almost immediately, and will then walk thirty or forty miles along the strike, and see the sandstones passing into shales, and a mass of gray slates, upwards of 6000 feet thick, interposed between the red and yellow beds and the limestone, will be prepared to understand and believe in changes of type quite as great as that which may have taken place between South Wales and Devon.

I am not without hope that to Ireland will be due the honour of setting at rest the *questio vexata* of the exact place, and value, and relations of the Devonian rocks, since in the south-west we have—in addition to this enormous expansion of beds between the mountain limestone and the regular old red sandstone—an equally great expansion of the lower part of the old red sandstone itself, a thickness of many thousand feet of red and green grits, interstratified with blue slates, rising up from below the ordinary old red, in the country between Macroom and Killarney.

When this country comes to be explored by the Geological Survey, we may hope it will yield some organic remains to the labours of our collectors, and thus give us the means of settling the question palæontologically as well as physically.

In connexion with this subject of the classification of the Devonian rocks, I would point out to your attention the papers by Mr. R. A. C. Austen, "On the Series of Upper Palæozoic Rocks in the Boulonnais," in the London Geological Journal; and the paper by Mr. W. S. Willson, entitled, "Notes on the Geology of the southern portion of the County of Cork," in our own Journal.

A local paper was recently laid before us by Mr. Triphook, descriptive of a section from Long Island to Mount Gabriel, in the neighbourhood of Skull, county of Cork, giving us a valuable de-

scription of facts, and indicating powers of observation from which we may hope still more valuable results in future.

On the palæontology of the Devonian Rocks, I find in the London Geological Journal the following papers:—

"Notice of the Discovery of Reptilian Foot-tracks and Remains in the Old Red or Devonian of Moray," by Captain Brickenden.

"A Description of the *Telerpeton Elginense*, a Fossil Reptile recently discovered in the Old Red Sandstone of Moray; with Observations on supposed Fossil Ovas of Batrachians, in the Lower Devonian Strata of Forfarshire," by Dr. Mantell.

"Notice of the Discovery of Fossil Plants in the Shetland Islands," &c., by Hon. H. Tufnell; and,—

"On some Fossil Brachiopoda of Devonian Age, from China," by Mr. T. Davidson.

There are several interesting papers on different portions of the carboniferous series, of which I would speak first of our Secretary's (Professor Haughton) paper "On the Newer Palæozoic Rocks which border the Menai Straits in Carnarvonshire." This paper, as you must have been aware, is a very excellent one in several ways, and as such is deserving of our careful attention and rigid scrutiny. I have no doubt of the accuracy either of the description of facts, or of the theoretical explanation of them, given in the first part of the paper, at the same time I would utter a word of caution on two points:—First, it is necessary, in attempting the explanation of the disturbances that have affected any district, and of the action of any igneous rocks that have been intruded into it, to make allowances for the possible wide differences in the condition that obtained when these effects were produced, from what exist at the present day. For instance: it is quite possible that when the faults and trap dykes were produced in the carboniferous rocks of the Menai Straits, that the rocks which still exist there were covered by a great thickness of other rocks that have since been removed by denudation. Secondly, it appears to me that Professor Haughton lays too much stress, perhaps unintentionally, on the actual intrusive trap as the disturbing agent. It seems to me impossible for any mere dykes of fluid matter, such as are there described, to have exerted any mechanical action of much consequence on the great sheets of solid rock about them. There must have been some great

mechanical force at work under the whole neighbouring district, which, at the time it produced the cracks and disturbances, allowed a passage here and there to some of the molten igneous rock below to insinuate itself into the fissures thus formed. I cannot suppose that the molten rock, while fluid, would in the mere form of a dyke exert lateral pressure sufficient to cause fractures or contortions in the surrounding rocks, though I can fully comprehend—on the supposition of the aqueous rocks having been first arched and fissured, and then penetrated by igneous rock—that that intrusive dyke, when cooled and consolidated, and when the rocks were settling down again, might prevent their occupying the same space as before, and thus cause lateral crumplings or subsequent shifts and dislocations. This modification of Professor Haughton's views would more nearly coincide with my own notions on the subject, though, on a question of pure physics, I should always be ready to rate his authority as of much higher value than my own.

The palæontological portion is worked out in a most careful and praiseworthy manner, and is valuable both as a description of the locality itself, and for the purpose of comparison with our Irish formations. It fully bears out Professor Haughton's conclusions, that there is in the Menai Straits no possibility of dividing the rocks into Carboniferous and Devonian. This, however, I for one should never have thought probable. The yellow sandstone of Dr. Griffith, in the north of Ireland, is undoubtedly part and parcel of the carboniferous formation, and with that the beds of the Menai Straits may very fairly be compared. Whether, however, the yellow sandstone of the south of Ireland be the same thing, or whether it be not a set of beds of similar lithological character, but occupying a much lower horizon, and belonging more properly to the old red sandstone, is another question. From the distinctive character of the fossils at Kiltorkan Hill, in the county of Kilkenny, viz., the *Cyclopteris Hibernicus;* the *Anodon Jukesii* (Forbes); the fossil fish; the *Pterygotus;* and the other plants; and from the two first named having again been found on the same geological horizon, close to the city of Cork,—this question seems likely to be answered in the affirmative. In that case, the carboniferous slate of the county of Cork may possibly turn out to be the transition beds from the Devonian into the carboniferous series.

We have had several minor papers on carboniferous districts

laid before us, of which I must content myself with giving the titles, for want of room to do more:—

1. "Remarks upon the Geology of the vicinity of Ballyshannon;" by R. Crawford, Esq.

2. "Notes on the Geology of the Country about Kingscourt;" by John Hamilton, Esq.

3. "On the Queen's County Collieries;" by Arthur A. Jacob, Esq.

On carboniferous palæontology there is, in the London Geological Journal for 1853, a highly interesting paper, by Sir C. Lyell and Mr. Dawson, "On the Remains of a Reptile (*Dendrerpeton Acadianum*, Wyman and Owen); and of a Land Shell discovered in the interior of an erect Fossil Tree in the Coal-measures of Nova Scotia; with Notes on the Reptilian Remains, by Professor Wyman and Professor Owen." And also one by Professor Owen, "On a Batrachoid Fossil in British Coal Shale." And one by Sir Philip de Malpas Grey Egerton, "On two new Species of Placoid Fishes from the Coal-measures."

In the London Geological Journal for 1853 there is also a paper by J. W. Dawson, Esq., "On the Albert Mine of Hillsboro', New Brunswick."*

This mine has been the occasion of much controversy, both of a scientific and legal character, in America. Mr. Dawson first shows the geological place of the rocks containing the mineral substance of the Albert mine to be at the base of the carboniferous series of that part of the world, "on the geological horizon of a singular band of pseudo coal-measures which occur in several places in Nova Scotia below the great lower carboniferous marine limestones." He then describes the curiously complicated contortions of the rock in which the mineral substance lies, and describes the nature of the substance itself. The controversy was as to whether this substance was a true coal, formed by deposition contemporaneously with the rocks in which it lies; or whether it was of the nature of a mineral vein, the bituminous substance having been subsequently injected or

* In the number of the London Geological Journal for February of this year, received just before sending these sheets to the press, are two papers by this gentleman, on the coal-measures of Nova Scotia, which appear to be of the highest interest and importance, but I have not been able as yet to do more than cast my eye over them, and can only therefore thus briefly point them out to your attention.

transported in some way into a fissure in the rocks. Mr. Dawson inclines to the former opinion; and so far as one may venture a judgment on a locality one has not visited, I am quite inclined to agree with him. From my experience in examining some of the faults affecting the thick coal of South Staffordshire, there seems to be nothing in the physical structure of the rocks of the Albert mine incompatible with the idea of its having been once a regular bed, and having assumed its present condition, and its present relations to the surrounding rocks, in consequence of the action of these forces of disturbance which Mr. Dawson points to. I have seen entanglements of coal and other rocks quite as remarkable as any there described; and we can easily conceive the possibility of even a still greater alteration of structure, compared with ordinary coal, taking place in a substance so easily acted on as coal, and containing so many excitable chemical components; an alteration that might be produced by the impulse of either chemical or mechanical forces.

It is singular that during the past year a case arose in Scotland of a somewhat similar character, in which I happened to be personally concerned. For various reasons I will trespass on your patience with a short account of this.

A dispute arose between the lessor and lessee of a mineral property at Torbane Hill, near Bathgate, Linlithgowshire, as to whether a certain mineral substance was coal or not. This substance occurred in an undoubtedly true bed, interstratified with other beds of the ordinary coal formation, and varying generally from a few inches to nearly two feet in thickness, but sometimes, as I was informed, thinning out altogether. In this respect, then, it did not differ from other beds of coal or other stratified rocks; moreover, all the beds were nearly horizontal, and not at all disturbed. The question raised was, whether it was coal or not; and a trial took place lasting several days, costing a vast expenditure of money, and involving the attendance of seventy or eighty scientific and practical men, many of them of the first eminence in their several pursuits. The evidence as to the chemical and other minuter characters of the substance was most conflicting; and while there was no dispute as to the physical circumstances of its occurrence, the geological opinions given may be stated as the three following:—

1st. That it was coal, although of a peculiar and unusual kind.

2nd. That it was not coal, *but* bituminous shale; the bituminous portion being originally mingled with the earthy matter.

3rd. That it was bituminous clay or shale; the bitumen having been injected into the clay, or in some way introduced into it, *subsequently* to the deposition of the rocks above it.

This latter opinion was inferred rather than directly expressed: it may be at once refuted, if refutation be necessary, by the fact of no true bitumen being now found in the mineral, but only the constituents of which bitumen is formed.

In the second opinion this fact was pointed out; "bituminous" being taken merely in the popular sense as "matter from which bitumen could be obtained." Strictly speaking, then, this should be called "carbonaceous shale." But we may ask, if a "bituminous" or "carbonaceous shale" be so highly inflammable or combustible as to burn freely of itself after merely being lighted, in what respect does it differ from coal?

I do not wish to speak in a merely popular sense, but in a strictly scientific one, to ask, what is coal?

Geologically, coal is not a "mineral," it is a "rock."* It is not a definite chemical compound; it is a mechanical admixture of various substances. These substances are usually vegetable and earthy matter: both the vegetable and earthy matter probably varying in kind, and having every possible variety in proportion.

But it does not appear to me to be absolutely necessary for the production of "coal" that it should contain any vegetable matter at all; since, if there were a sufficient quantity of *animal* and earthy matter to produce the requisite proportion of carbon and hydrogen, in the resulting rock, to emit flame and support combustion on heat being applied to it, I know not how geologists could refuse to call it coal. I believe that some of the Kimmeridge coal, in the lower part of the Kimmeridge clay, derives its carbon and hydrogen from the decomposition of animal rather than vegetable matter. Geologically, then, there is every possible gradation from coal into carbonaceous or bituminous shale; and it is impossible to say where one

* Coal and its allies—"jet," "amber," &c.,—ought to be removed from mineralogical treatises, as not minerals in any true mineralogical sense. They should be considered as either "rocks" or "fossils." A "mineral" ought to have a definite chemical composition and a *definite crystalline form*, as well as certain constant physical characters.

ends and the other begins; the single test, both scientifically and practically, being whether it will "burn" or not.

In the January Number for this year of the Quarterly Journal of Microscopical Science there is a paper by Professor Quekett, "On the Minute Structure of the Boghead Cannel Coal." In this paper Professor Quekett puts forward some views which are at least new to me, if not to geologists in general. He states, that all coal is "fossil wood," and is rarely, if ever, composed of the plants such as Stigmaria, Sigillaria, Lepidodendra, &c., which are found associated with it. He also states his belief that anthracite is "fossil coke;" in which expression, however, he may perhaps use "coke" merely as a synonym for carbon.

Any new discoveries, as to the minute structure of coal in general, made by a man of Professor Quekett's acknowledged eminence, will, I am sure, gentlemen, be received by all geologists with the greatest delight. I would, however, with all respect, venture to ask Professor Quekett not to rest satisfied until he has not only examined many hundred specimens of coal from different localities, but also many which he would find it impossible to procure unless by his own hands in the mines themselves.

Every important seam of coal is made up of two, three, or half a dozen beds, and each bed of a multitude of layers; both the beds and the layers differing widely in character, and, doubtless, in composition. In one part of a compound seam of coal, one bed will be good coal and another worthless, while at a distance of a hundred yards or two they will have altogether interchanged characters. Cannel coals will pass into bright coals; sulphur coals will become pure and fit for use; bituminous coal will pass into anthracite; stone coal into caking coal, or the reverse; and all without any appearance of disturbing agency, or other change in the conditions of the rocks about them. Many coals that are "gotten" and used for manufacturing purposes on the spot are never brought into the general market at all.

Before, therefore, any microscopical or other characters can be established as essential to the existence of coal, all these kinds of coal must be examined in all their minute and local varieties. But even then, supposing that we went to the extreme of proving that all other coals in the world exhibited certain microscopical characters in which the Boghead Cannel was deficient, would that prove it not to be coal? Certainly not; it would merely show it to be a

very peculiar variety of coal, which was *sui generis* so far as those microscopical characters are concerned. For if not coal, what is it? To this the only answer that has been returned is, "bituminous" (i. e. carbonaceous) "shale." To which I reply again, that shale which is sufficiently carbonaceous to support combustion is to all intents and purposes coal. Not that I look upon the Boghead coal as a shale; because one of the essential characters of a shale is an easily fissile lamination, while the Boghead coal is singularly compact, with a conchoidal fracture. It is, in fact, a peculiar variety of Scotch cannel coal.

There are still a few of our papers, gentlemen, not yet noticed. Lord Talbot de Malahide has, on two occasions, laid before us some very interesting fossils from distant countries: once from South Australia, and once from Egypt. Of the latter you will find an account in the last Number of our Journal, entitled, "Notes on the Geology of Egypt."

There are also several papers descriptive of the analysis of certain mineral substances, of which I have only space to give the titles:—

1. "Notes on the Serpentines of Cornwall and Connemara;" by Rev. Professor Haughton.

2. "Account of the Gangue of the Conlig Lead Mine, County of Down;" by Rev. Professor Haughton.

3. "Notice respecting a variety of Magnetic Ire Ore;" by Dr. Apjohn.

4. "On an Analysis of Euclase;" by J. W. Mallet, Esq.

5. "Results of an Analysis of Siliceous Deposits from Hot Volcanic Springs of Taupo, New Zealand;" by J. W. Mallet, Esq.

Lastly, I must mention, much more briefly than it deserves, a paper by our Secretary, Professor Haughton, "On Ballymurtagh Sulphur and Copper Mine;" one apparently of a series that we may expect to receive from him.

In connexion with this I may also call your attention to the recent publication, in the "Records of the School of Mines," of a paper "On the Mines of Wicklow and Wexford," by Mr. Warrington W. Smyth, Mining Geologist to the Survey.

This paper gives an account of the structure of the mineral veins, of the relations that may be traced between their directions, and of the practical working and statistics of the mines. In the latter portion there is a little discrepancy between the Table of the production of the Ballymurtagh mines, as given by Professor

Haughton, and that given to the Survey by Mr. Barnes, the Resident Director. Professor Haughton's Table underrates the production of copper during the eight years closing with 1851, by upwards of 4000 tons, and that of pyrites by more than 2400 tons.

Had this Address not already extended to such an unconscionable length, I should have detailed to you the progress of the Geological Survey of Ireland during the past two years, and have pointed out to you, and through you to the public at large, a plan by which its labours could be made practically useful and beneficial to every one possessed of, or having the management of, landed property. As it is, I can only say that we have now reached Bantry in our progress to the south and west; that the revision of some of the earlier work, for the purpose of publication on the new Inch Sheet Map, and for the compilation of a Report, is begun; and that, generally, we have made as much progress in our work as was possible with the very scanty staff and the very inadequate means that have hitherto been placed at our disposal. On a future occasion I hope to give you something more definite, and announce results of a more gratifying character.

That this Address has reached the length it has is not altogether my fault. My worthy friend and predecessor, Dr. Ball, must be content to share the blame with me, since he has imposed upon me a double task.

There are several subjects and several publications on which I meant to have made remarks, which, for want of space, I am compelled to omit. Among these I would especially mention, the Report on the Geological Survey of Wisconsin, Iowa, and Minnesota, by David Dale Owen, Esq.; and Professor James Forbes's book on Norway and its Glaciers.

The very mention of two such books, so admirably written, so beautifully illustrated and descriptive of the geological structure of countries that even in my early days it would have been considered an actual distinction to a man to have visited, at once brings before our minds, in the most vivid light, the wonderful extension of our science during the last half century. The world at large, gentlemen, may have been regardless of the labours of geologists, and indifferent—as, alas! too many of its inhabitants are—to the wonders and the beauties by which they are surrounded; for many of these wonders and beauties can be seen only through the glass which is held in the hand of Science.

In all parts of the globe, however, we have now, and for many years have had, a band of fellow-labourers, united to us in spirit and in the common interest of a kindred pursuit. It is to societies such as this—as I well know from experience—that many earnest men look for the ultimate appreciation of their labours, when, but for that distant hope, their spirits might perhaps have flagged under the toils, and privations, and dangers to which they have been exposed. If it were for this consideration alone,—namely, in order that we might form one of the central temples in which the sacred torch of Science should be kept alight, to throw a beam of encouragement and approval over the scattered bands of her worshippers in all corners of the earth,—it would be our duty, if it even were not also our pleasure, to use every means in our power to make secure the basis and extend the superstructure of our Society. For such a noble end some little personal sacrifice of time, or of money, or of exertion, is incumbent on us all. Geologists have ever been remarkable, perhaps above every other class of scientific men, for the cordial union, the hearty good fellowship, which has knit them together into a band of brothers. Their contentions and dissensions have almost ever been kept down to mere means of eliciting the spark of truth by the collision of various intellects, or at most have been displays of personal strength and skill, knightly combats in all honour and love, preceded and ended by the cordial shake of the hand, which is the manly habit even of our common pugilists. Much of this good-humour is doubtless owing to the out-of-door and robust nature of our pursuits leading us to take that kind of combined mental and physical exercise most conducive to the production of the *mens sana in corpore sano.* Something, also, is owing to the example set us by the great men who were the founders of our prototype, the Geological Society of London.

Allow me to hope, gentlemen, that along with the scientific and economical benefits which our science has conferred upon the world, it may still remain the boast of Geology that she has contributed her share to this moral benefit also,—that philosophers can differ in opinion without loss of temper, and without loss of respect for their opponents; and that while each is conscious of his own single aim at the discovery of Truth, he is ready to give credit to any one for the same singleness and directness of purpose, who may fancy that she lies in an opposite direction.

March 8, 1854.—"On the Character and Mode of Occurrence of the Dolomitic Rocks of Kilkenny;" by ANDREW WYLEY, Esq.

BEFORE entering upon that which is more immediately the object of the present notice, it will be necessary to advert generally to the carboniferous limestone of this part of Ireland, in which the above rocks form no insignificant feature.

The great granite axis which commences to the south of Dublin Bay, and stretches uninterruptedly through Wicklow, Carlow, and Wexford, a distance of about eighty miles, terminates in the Hill of Brandon, in the south-east of Kilkenny. On its flanks rest the upheaved slates, supposed to be of lower Silurian age. A few detached outliers of the granitic mass occur beyond this point, and on the denuded surface of the largest of these, the old red sandstone is seen to rest in undisturbed and nearly horizontal stratification. Its lower portion contains pebbles and angular fragments of the granite, aad many of its beds are derived almost exclusively from the waste of that rock.

The age of the granite is thus decided as being intermediate between that of the slates above mentioned, and the period of the old red sandstone.

The old red sandstone of Kilkenny is of very insignificant thickness, in comparison with the vast accumulation of Devonian deposits in the south and west of Ireland. In no case does it amount to much more than 1000 feet. It may be divided into two portions, a lower and an upper.

The former, or old red sandstone proper, consists of conglomerates, alternations of red argillaceous sandstones, shales, and mudstones, or consolidated marls, with an imperfect cleavage. So far as it has yet been examined, it has afforded no traces of organic life.

The upper division, or upper Devonian, in Kilkenny, is usually made up of yellowish or light-coloured sandstones and shales, and contains abundant remains of land plants, and more rarely fresh-water shells, the plants being very similar in general aspect to those occurring in the coal-measures.

To this succeeds the carboniferous limestone, which is well developed, attaining to a thickness of about 4000 feet. It is here peculiarly interesting, as affording the best type of this formation hitherto met with in Ireland. The districts previously examined

by the Geological Survey presented great obstacles to a proper understanding of the relations existing between the subordinate members of the limestone series; still less did they afford any clue to the local changes so common in this class of rocks. The thick covering of drift accumulated on the low-lying plains of Dublin, Kildare, and Carlow, conceals the rock except at intervals widely remote from each other, and renders any intimate acquaintance with such changes of structure nearly impossible. In these counties we have the same modifications of the limestone as in Kilkenny, but from the reasons already mentioned, we could arrive at no definite conclusions with respect to them. The Kilkenny limestone being comparatively free from drift, is therefore deserving of particular attention, as affording an index or key to the more obscure districts.

The carboniferous limestone of the east of Ireland is usually separated into three great divisions:—

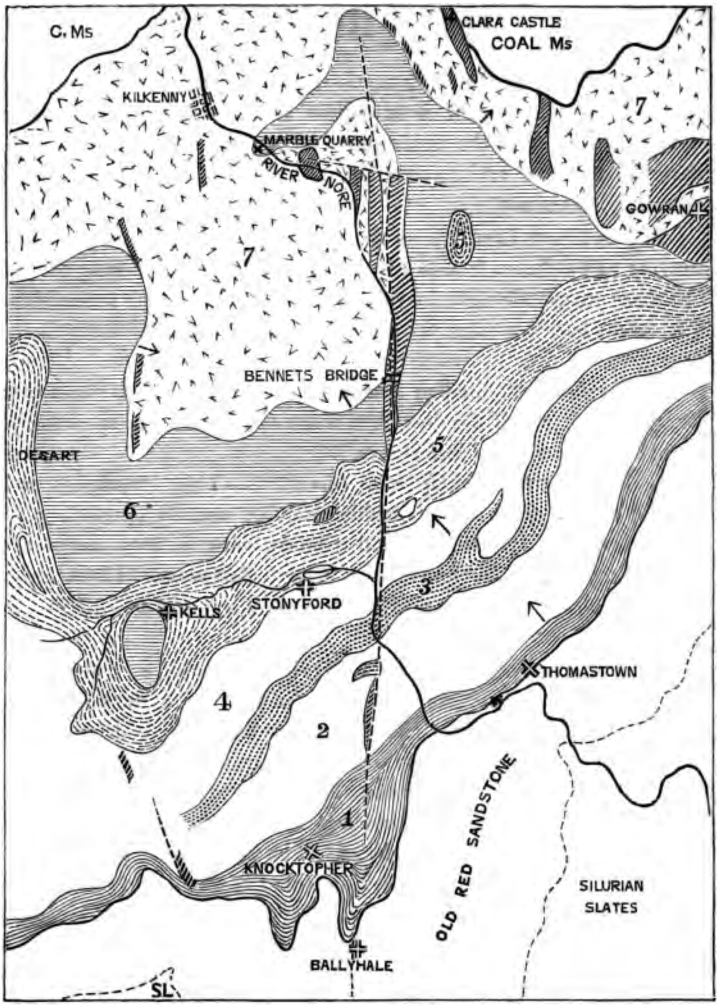
1. The upper limestome.
2. The middle or calp limestones and shales.
3. The lower limestone.

The last of these, the lower limestone is of a very complex character. Its lower portion, that resting immediately on the sandstone, consists almost entirely of muddy shales, whilst its general mass is split up by two remarkable belts of magnesian limestone, themselves very different in character. Viewing it lithologically, therefore, it presents five well-marked subdivisions.

Here is a tabular view of these, with the approximate thickness of each, as deduced from the somewhat imperfect sections the Kilkenny district affords.

		Feet.
Upper limestone,		1500
Middle or calp limestone,		820
Lower Limestone,	Upper magnesian and cherty limestone,	250
	Shaly fossiliferous limestone,	830
	Lower magnesian limestone,	200
	Lower limestone proper,	650
	Lower shales,	450
	Total thickness,	4200

The annexed geological outline will give some idea of the superficial area occupied by each of these subdivisions. We shall now take a rapid glance at them separately, beginning with the lowest.



Scale, 3 Miles to 1 Inch.

Map of the Carboniferous Limestone of Kilkenny.

7	- - - - - - - - - - - - - - - - - - - -	UPPER LIMESTONE.
6	- - - - - - - - - - - - - - - - - - - -	CALP LIMESTONE.
5	**Upper Magnesian and Cherty Limestone,**	LOWER LIMESTONE.
4	**Shaly Fossiliferous Limestone,**	
3	**Lower Magnesian Limestone,**	
2	**Lower Limestone Proper,**	
1	**Lower Shales,**	
	Metamorphic Dolomite,	**Lines of Fault.**

1. *The Lower Shales.*—These consist of black or dark-gray muddy shales, with thin layers of sandstone towards the base, and some beds of limestone in the upper part. They are usually very fossiliferous,—spirifer, orthis, crinoids, and foraminated corals, being especially abundant.

2. *The Lower Limestone proper.*—Dark-gray limestones, in beds, varying in thickness from six inches to two feet, separated by shales, but these are usually thin, merely forming a shaly coating to the beds. The fossils here are much the same as in the last, but more regularly distributed.

3. *The Lower Magnesian Limestone.*—This, as well as the upper magnesian band, will be described more at length when speaking of this particular class of limestones.

4. *Thin Earthy Fossiliferous Limestone.*—Thin limestones and nodular shales, of a gray or blackish colour, usually abounding in fossils,—orthis, turbinolopsis, and crinoids, being the most common.

5. *The Upper Magnesian and Cherty Limestone.*—Light gray, granular, magnesian limestone, with irregular bands and nodules of chert.

6. *Middle or Calp Limestone.*—This is represented by dense, compact, or finely crystalline limestone, usually of a dark gray or blackish colour, with or without shale partings; the beds generally thin and regular, presenting a greater parallelism than is usually met with in the other limestones. Fossils for the most part are rare, though large productæ are abundant in some particular beds, and fucoids are met with in the shales. The dark colour and compact texture so common to the calp limestones render them susceptible of a high polish, and they afford a glossy jet-black marble, but only a few of the thicker and less splintery beds are available for this purpose. This quality seems to be due to the presence of carbonaceous matter, but seldom amounting to more than one-third per cent., as is shown by the analysis of a specimen possessing the above characters in a marked degree.

7. *The Upper Limestone.*—Thick-bedded, massive, coarsely crystalline limestones, for the most part of a grayish colour. They are unusually free from shales and foreign matter generally, consisting almost wholly of pure carbonate of lime. They contain fossils in greater variety than any other division of the limestone. Some beds appear altogether made up of crinoidal *debris*, while others are one mass of productæ. The transition from the sparingly fossil-

iferous beds of the calp to the upper limestone, so rich in organic remains, is remarkably abrupt. In the very lowest beds of the latter we find large masses of the stony corals,—lithodendron, cyathophyllum, syringopora, and others,* though hardly a solitary specimen of any of these is to be met with in the calp or in the beds below.

Upon the upper limestone, the shales and grits of the coal-measures rest, apparently in conformable stratification.

Having thus given a general outline of the subdivisions of the carboniferous limestone, we may now proceed to inquire more minutely into the nature and relations of the dolomitic varieties, or those containing a considerable amount of carbonate of magnesia in their composition. The proportion of the latter in the ordinary limestones is very variable. The upper limestone often contains less than 1 per cent., while in some of the beds of the calp and lower limestone, it makes up from 3 to 6 per cent. of the mass. Even in this small proportion its presence is sufficiently evident to the eye, giving the limestone a granular and somewhat glistening appearance. It usually exhibits a greater density, and has a ringing metallic sound when struck by the hammer. On burning, it produces what is called a hot lime, and is generally avoided, as being too caustic in its action for agricultural purposes. For building it appears equally well adapted with the purest lime.

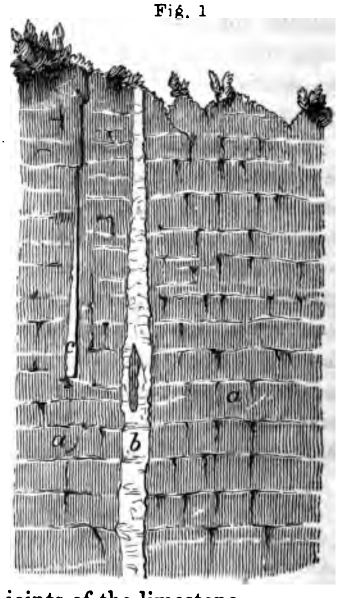
So long as the magnesia keeps within these limits, the rock may be regarded as a limestone, but where it amounts to 12, 20, or 40 per cent. of the mass, it can hardly be considered as such, so far even as its practical uses are concerned. It is then difficult to burn, so much so, that it is often used in the construction of kilns for burning the ordinary lime, in the absence of better materials, and even when burnt, it would be of use only to the manufacturing chemist, who extracts the magnesia it contains. It is therefore of importance that these two rocks, the limestone and the magnesian limestone, so different both in their mineral constitution and in their economic relations, should be carefully discriminated.

* It is a remarkable fact that these fossils, according to Professor Phillips, characterize the lower scar limestone of Yorkshire. Similar aggregations of fossils have been noticed by the Rev. Professor Haughton in his recent paper on the Carnarvon limestones, as occurring high up in those beds, at Vaynol Wood and Bryn Adda. Considering these beds to represent the upper limestone—the calpy limestones below, and the coal-measures above, would bring them very near to the Kilkenny type.

When we come to examine the magnesian limestones themselves, we find them to vary not only in their chemical composition, but in their mode of occurrence and their probable origin. They seem to be divisible into two strongly contrasted groups, the contemporaneous and the metamorphic dolomites; holding towards each other a relation somewhat analogous to that which exists between a stratified ash-bed and an intrusive greenstone. The dolomitic rocks, in the one case, appear to have been deposited contemporaneously with the limestones, while in the other they have undoubtedly resulted from an alteration of the previously deposited limestone, by the introduction of magnesia at a subsequent period. We may now bring forward some of the facts that have led to the above conclusion.

For the sake of distinction we shall confine the term dolomite to the latter class, or those produced by a metamorphism of ordinary limestone, as containing the largest amount of magnesia, while those which appear of contemporaneous origin may be called simply magnesian limestones. We commence with the former, as presenting the most decided character.

Fig. 1



1. *Metamorphic Dolomites.*—In many parts of Kilkenny the limestone is seen to be traversed by dyke-like masses, or irregular patches of a light-brown crystalline rock, differing very much in chemical composition and general aspect from the body of the limestone. One of these, occurring at a quarry at Oaklands, near Callan, is represented in the adjoining sketch.

a, *a*, thick beds of gray crystalline limestone.

b, a vertical dyke (as it were) of yellowish-gray dolomite, crossing the beds at right angles, and varying in thickness from one to two feet, apparently occupying the space between two consecutive joints of the limestone.

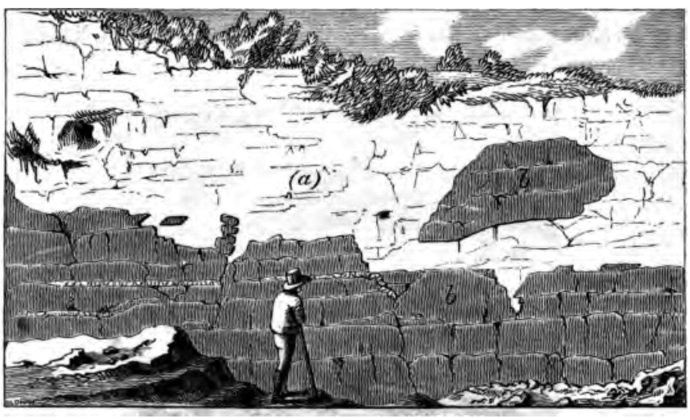
c is a smaller dyke, parallel to the last.

The transition from the one to the other is exceedingly abrupt, and the appearance to the eye is verified by the chemical analysis of the rocks. A portion taken from the interior of the dyke gave $23\frac{1}{2}$ per cent. carbonate of magnesia, whilst the limestone in immediate contact with it contained little more than 2 per cent. A specimen taken at six feet distance, and representing the ordinary limestone of the quarry, differed in no respect from the last, showing clearly that there was no gradation into each other.

The dyke is so much disintegrated, that it is impossible to see whether the planes of bedding of the limestone are carried through it, and at first sight it would suggest the idea of its having been intruded bodily, or else deposited in a vertical fissure, like an ordinary mineral vein; but other cases, where the original bedding is seen, and where the half-effaced marks of the fossils are still traceable, at once negative either of these suppositions.

In the absence of any other way of accounting for the matter, we are forced to the conclusion that the dolomitic portion is only the ordinary limestone altered and metamorphosed by the subsequent introduction of magnesia; such alteration having taken place along certain joints or fissures of the rock. How, or in what form the magnesia was introduced, is a matter which may be left for future consideration.

Fig. 2.



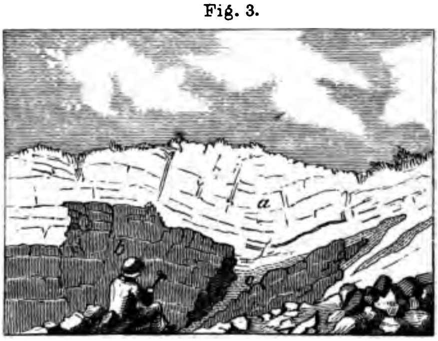
In the annexed sketch of part of a large quarry, in the upper limestone at Ballykeefe Hill, between Callan and Kilkenny, the dolomite (*a*) is seen to assume a different form. It here traverses

the limestone (*b*) in a very capricious manner, at one time conforming to the beds, at another, cutting into and across them, and sometimes including large masses of the limestone unaltered. In its colour and general outline it has much the appearance of an irregular vein of felspathic granite. It contains druses lined with bitter spar, and frequently exhibits open caverns and fissures, but the last is a feature common to all the limestone rocks.

In this, as in the preceding case, the transition from the limestone to the dolomite is quite abrupt; there is no passage or gradation from the one to the other. The limestone is remarkably pure. Two specimens, one close to the dolomitic mass, and the other taken at several feet distant, were found almost exactly alike in composition, each yielding above 99 per cent. of carbonate of lime, and less than 1 per cent. carbonate of magnesia. The dolomite, on the other hand, contained 42 per cent. of the latter, and only 56 per cent. carbonate of lime. Theoretically, 52 parts carbonate of lime would combine with 42 of carbonate of magnesia ; so this comes sufficiently close to the mark to be regarded as a definite compound, and therefore a true or typical dolomite.

It is not quite uniform in composition, and the disseminated crystals, which in size and disposition resemble those of the unaltered limestone, would appear to contain less magnesia than the general mass. The traces of encrinite stems are still discernible, similar to those in the limestone. All these circumstances taken into account point to the conclusion, that it is only that limestone in a chemically altered state.

Fig. 3.



In Fig. 3 is represented the relation of the limestone and dolomite, as seen in a small quarry half way between Stonyford and Bennetsbridge.

(*a*) is the yellowish crystalline dolomite, as before, resting upon the limestone (*b*); the figure sufficiently explains the irregular nature of the junction.

It is worthy of remark, that while the limestone is of a compact or fine-grained texture, the dolomite is almost as coarsely crystalline as in the last two cases.

(*c*) is a small patch of black granular magnesian limestone, differing both from the ordinary limestone and the dolomite overlying. It is seen at one or two points along the junction, and occupies the crack or fissure (*c*), presenting a very puzzling appearance, and one not easily accounted for.

The above illustrations have been selected, as presenting, within a moderate compass, all the facts necessary to a proper understanding of the subject; but we have instances of the conversion of limestone into dolomite on a much more extensive scale.

One of the best of these is to be seen along the river Nore, at Bennetsbridge. The course of the river here is nearly due south, apparently along a fault in the limestone. This fault is well seen in the sandstone at Mullinavat, about fifteen miles to the southward, and its throw there cannot be less than some hundreds of feet. Along the river Nore, and coinciding with this line of disturbance, is seen an extraordinary development of dun-coloured crystalline dolomite, commencing about a mile below Bennetsbridge, and traceable with little interruption for four miles in a northerly direction. In one place, where it is cut across by a brook, it is shown to be nearly half a mile in width. North of Bennetsbridge it forms a perpendicular cliff along the eastern bank of the river for a considerable distance. Here its beds are very indistinct, and its open vertical joints give it a marked columnar character. At other points the stratification is sufficiently evident. It contains geodes and nests of calcareous and bitter spar, and has besides, many empty, rounded cavities of small size, looking like places from which fossils had disappeared. There are also several open fissures and caverns, as in the former example at Ballykeefe Hill. In composition it seems to be exactly identical with the rock of that place, and may therefore be regarded as a true dolomite.

Several large masses of the same rock occur to the N. W. and appear to range north and south like the preceding; the unaltered upper limestone being included between them.

At Coolgrange, about five or six miles to the eastward of Kilkenny, is a small glen in the upper limestone, running north and south. For a distance of nearly half a mile the one side of the glen consists entirely of gray limestone, while the other, only a few yards distant, consists of yellowish dolomite. Both strike across the glen, and both have a dip of from 10 to 15 degrees to the N. E. The dolomite is between 200 and 300 yards in width, and on the western side abuts against the limestone in the same manner.

Although there is in all probability a crack or fissure running along the bottom of the glen, there does not seem to be any considerable displacement of the rocks on either side. If, however, we were ignorant of the peculiar habits or mode of occurrence of the dolomite, we should undoubtedly assume a downthrow of some hundred feet; but with the facts above described to guide us, the occurrence of a large mass of limestone abutting against a mass of dolomite in the same strike presents no difficulty.

It is worthy of notice, that in all these instances the dolomitic dykes or masses, so far as they can be traced, range as nearly as possible north and south, which corresponds with the direction of the leading joints and larger lines of fracture in the district. Indeed, so much is this the case, that the occurrence of dolomite in any place may be regarded as a certain indication of some disturbance having taken place in the original rock. In the south-east portion of the limestone district, about Thomastown and Knocktopher, where the beds remain in nearly a horizontal position, they seldom if ever occur, and the first indication of them we have is about two miles west of Knocktopher, where a sudden dislocation and folding of the lower limestone takes place.

At Clara Castle, about two miles north-west of the dolomite last described, is another extensive tract of the same rock. It here occurs in the very highest part of the limestone, immediately beneath the coal-measures, and ranges about N. N. W.

By far the greatest development of dolomitic rocks of the altered class is to be found in the neighbourhood of Gowran, towards the base of the upper limestone. Here, a tract of about three square miles, with the exception of a few patches of unaltered limestone, seems entirely composed of them. Owing to the greater prevalence of drift in this district, the mode of occurrence of the dolomite cannot be so well traced as in the foregoing instances. It presents,

however, exactly the same lithological character, and the only respect in which it differs from them is, that instead of having a determinate north and south direction, it possesses an irregular semicircular outline; in this case it would seem marking not so much a line as a centre or focus of disturbance.

Enough has been said to show the habits and character of these remarkable rocks, and it would seem to me, that if the appearances they present be carefully weighed, we must come to the conclusion that they have been produced by an alteration of the limestone by the introduction of magnesia at a period subsequent to the deposit, and, it would be easy to show, even after the consolidation of that limestone.

2. *Magnesian Limestones.*—We now proceed to an examination of the second class of dolomitic rocks, or those assumed to be of contemporaneous origin.

It might at first sight seem very easy to decide whether a series of rocks, forming, as these do, a very extensive feature in the geology of Kilkenny, have been deposited contemporaneously, or have been produced, as in the case of the dolomites already described, by the alteration of an original limestone deposit; yet this is found to be a very difficult point, owing to the ambiguous nature of the rocks in question, which possess certain characters that may accord with either hypothesis.

This will be better seen when we have given a short description of these rocks.

In the previous general notice of the lower limestone, two broad magnesian bands were pointed out, separated by beds of earthy fossiliferous limestone. By the gradual thinning out of the latter, the two bands merge into one broad single belt, to the northward, near the town of Gowran. As they differ materially in character, they may be considered separately.

Upper Magnesian and Cherty Limestone.—From the town of Kells this limestone may be traced, stretching away in a north-eastern direction, forming a pretty uniform and continuous belt, varying from two miles to less than one mile in breadth. Uniting with the lower magnesian band at Gowran, it holds on its course to the boundary of the county, passes through the whole length of the county Carlow, and though nearly lost in the mass of drift which it there encounters, shows at intervals in the county of Kildare. It

thus has a course of at least forty miles. Throughout all this distance it appears to conform to the bedding of the general mass of the limestone. From Kells it continues westward for a short distance, when it becomes involved in a great contortion of the limestone; and though it is here very difficult to follow it with certainty, there is reason to believe that it presents the same conformability throughout. This should be borne in mind, as it presents a strong argument for its contemporaneous character.*

In composition it may be described as a very fine-grained, glistening magnesian limestone, of a gray or light-gray colour. It is sometimes almost a pure white, and then merits the designation of saccharoid limestone better than the marbles to which it is usually applied. It is greatly cut up by joints, and readily decomposes, more so, it would seem, in the interior than where exposed to full atmospheric action. It is often siliceous, and contains numerous nodules and irregular bands of chert. These are found almost in every part of it, and separate it into layers more or less distinct. Owing to this want of uniformity in its composition, the rock on weathering assumes a very massive and rugged character.

It contains crinoidal *debris*, and other fossils, but these are of rare occurrence, except in some of the siliceous beds towards the base. One of the most striking features of this rock is the vast number of druses or cavities that occur in it, lined with calcareous or bitter spar, and very frequently with small crystals of quartz.

Unlike the dun-coloured dolomite already described, it varies much in texture and chemical composition. The light-coloured and more glistening varieties contain about 22 per cent. of carbonate of magnesia, while the more common gray kinds contain only from 13 to 14 per cent. The chert for the most part is nearly pure silica, with only a trace of lime and magnesia.

The Lower Magnesian Limestone.—This lower band is covered by drift to the southward, and first appears in the hill of Knockadrina, near Knocktopher. From this it stretches to the northward, with a breadth of more than half a mile, holding a direction nearly parallel to the belt already described for eight miles or more. The two then gradually approach each other, at length join, and hold on together through the county of Carlow.

* In speaking of the contemporaneous or non-contemporaneous character of the magnesian limestones, we refer of course only to the magnesian element.

This rock has a very peculiar aspect. It has the same granular, glistening character as the last, but in a more eminent degree, the small crystals glancing like spangles of black mica. It is always of a dark-gray or blackish colour, owing, most probably, as in the case of the calp limestones, to the presence of a small quantity of carbonaceous matter.

It also contains drusy cavities, but these are not at all so common as in the upper band. They usually contain transparent quartz crystals. These sometimes reach three or four inches in length. Numbers of them may be seen glancing in the sun, where the plough has newly turned up the decomposed surface of the rock.

It shows a very distinct and regular stratification. The bands and nodules of chert so common in the last are here altogether wanting. It is easily disintegrated, owing apparently to the peculiar form and arrangement of the crystals, and may be seen decomposed, for several feet in depth, into a heavy black sand, looking not unlike coarse gunpowder.

This limestone is singularly devoid of organic remains; throughout its greater portion no trace of a fossil is discernible.* It is only a few beds, near the top and bottom of the series, that contain even encrinite stems in any quantity. In this respect it presents a marked contrast to the limestones in immediate juxtaposition with it. Both the limestones below, and those resting upon it, are highly fossiliferous.* The latter particularly, occurring between the two magnesian bands, seems half made up of organic *debris*. Now this would appear to accord best with the notion that the magnesia was deposited with the limestone. The carbonate of magnesia, if we may judge from its effects upon the vegetable world, would not be at all favourable to animal life,—and a large amount of this, existing in the deposit under consideration, would account for its non-fossiliferous character. If, on the other hand, the rock had been deposited simply as a limestone, and the magnesia was added subsequently, we can hardly imagine how it so completely effaced the fossils that limestone would have undoubtedly contained. The magnesia here, it should be borne in mind, is not by any means in such quantity as in the dun-coloured dolomites first noticed, and even in these the fossil marks are still traceable.

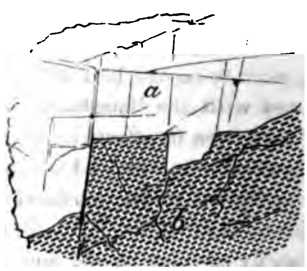
* Traces of fish have been found in it, but limited, I believe, to a single palate.

So far the evidence is wholly in favour of the contemporaneous origin of the magnesia in these limestones. Their great diversity of composition; their general conformability to all the bendings and undulations of the limestone mass; the great distances to which they may be traced, without the slightest interruption, so different, in these respects, from the true dolomites; the evidence their want of fossils appears to afford, that the sea-bottom of their time contained some unusual substance which interfered with animal development,—make out a strong case in favour of the above view, that the magnesia and lime have been deposited simultaneously.

We would not have much hesitation in adopting this conclusion were it not for some extraordinary appearances presented by this rock at its junction with the ordinary limestone, which would lead to an opinion exactly opposite.

About a mile south of Stonyford, the magnesian beds are much mixed up with the limestone, and in one particular quarry the two inosculate very strangely, a portion of the magnesian limestone projecting into the ordinary limestone. The beds of the latter are nearly horizontal, and are crossed by vertical joints; for a short distance along some of these, all is common limestone on one side, and magnesian on the opposite, the beds abutting against each other, apparently without any fault or displacement.

Fig. 4.



This will be understood by a reference to Fig. 4, which represents the mode of junction in plan—(*a*) being the limestone, and (*b*) the magnesian beds.

In this instance, that conformability, which, if the two were of contemporaneous origin, we should expect, is decidedly wanting; and we shall find it very difficult to account for such appearances without having recourse to the alteration hypothesis. But if we apply this hypothesis to the whole of these limestones, let us see to what it would lead us. We must then take it for granted that the altering agent, the magnesia, instead of following the capricious and irregular course we found it to take in the case of the true dolomites, instead of confining itself to distinct lines and centres of disturbance, found its way to a certain set of beds alone, and followed these in all their windings.

It is true that the cases are somewhat different. The true dolomites usually occur in the solid and massive upper limestones, where the altering material would have great difficulty in finding its way along the lines of stratification; and as the alteration must have proceeded from below upwards, that it should have more of a partial or local character in the higher beds is what we should only expect. Yet, giving all these considerations their full weight, they are not sufficient to account for the totally different modes of occurrence presented by these two classes of rocks. A glance at the map will show this dissimilarity better than any description, a dissimilarity hardly reconcilable with the idea that they were produced in the same way.

If the magnesian character of these bands of limestone was owing to the introduction of magnesia along a certain set of beds, we cannot readily perceive why other beds, lower in the series, and through which also it must have passed, escaped.

In the upper magnesian beds we find nearly everywhere bands of chert. These last were undoubtedly of contemporaneous origin, and we see no good reason why, if the magnesia was added subsequently, it should confine itself to the beds in which was the chert, and to these alone. It is much more natural to conceive that the three—the lime, the magnesia, and the silica—were all in the course of deposit together.

Though the evidence is thus somewhat conflicting, the balance would seem to be in favour of the magnesia having been deposited at the same time as the lime stone. But a certain amount of alteration appears to have taken place in the limestones adjoining this magnesian deposit, at a later date, possibly by a transfusion of a portion of the magnesia from the latter to the limestones in immediate contact with it. If this were admitted, it would sufficiently account for the irregular nature of the junction of the two rocks already described, and would leave little doubt on our minds of the magnesia in these limestones having been of contemporaneous origin.

We have thus seen that one class of dolomitic rocks, usually of yellowish colour and coarsely crystalline texture, have clearly been produced by a metamorphosis or dolomitization of previously deposited limestones; and that in another class the magnesia and the lime would appear to have been thrown down together. In the

latter case, the grounds of our conclusion are uncertain, and its correctness remains to be tested by future observation.

General Conclusions.—The true history of these magnesian rocks would seem to be something to the following effect:—

The vast accumulation of calcareous matter, existing in the limestones, can be accounted for only on the supposition of mineral origin. Much of it is, no doubt, made up of organic exuviæ, but these must be regarded as an effect rather than a cause. During the preceding period, that of the old red sandstone, the quantity of calcareous matter existing in the sea must have been very small. It is only in the uppermost beds that we find the slightest traces of it, or the fossils by which it is usually accompanied. We cannot then imagine how the great assemblage of shells and corals which meet us at the very commencement of the limestone period obtained the material so necessary to their economy and actual existence, without supposing a great change to have taken place in the sea-bottom in which they lived, without, in fact, assuming a sudden increase in the quantity of carbonate of lime held in solution, or in mechanical suspension by its waters.

This is usually accounted for by supposing a great outburst of this material, in the form of mineral springs arising through large cracks or fissures. In the case of the Kilkenny rocks, these springs supplied simple carbonate of lime at first, but at the period marked by the deposit of the magnesian beds we have been describing, carbonate of magnesia seems to have been also poured out in greater or less quantity, rendering the sea-bottom of the period less favourable to animal life. During the remainder of the carboniferous limestone epoch, the deposits consisted almost exclusively of carbonate of lime.

The magnesia in the true or metamorphic dolomites must be referred to a different source and different period.

We have already seen, that, after the deposition and consolidation of the upper limestone, various cracks and fissures took place in its mass. Through these the altering agent, the magnesia, seems to have found its way, probably in the form of an aqueous solution of its carbonate,—the well-known hypothesis of Von Buch, ascribing the alteration to magnesia in the form of vapour, arising from augitic rocks beneath the limestone, being now generally given up as untenable. This change or dolomitization of the

original limestone was not produced by the addition of a certain amount of carbonate of magnesia, but rather by a double decomposition of the two carbonates. The original limestone gave up nearly half its lime, replacing it by a corresponding amount of magnesia abstracted from the aqueous solution of its carbonate, then infiltrating. The latter would then pass out as carbonate of lime, or a mixture of carbonate of lime and carbonate of magnesia.

This is the result which, from chemical considerations, we should expect, and that it has been the case is shown by comparing the relative densities of the altered and unaltered rock. These are found to be nearly the same. Now it is plain that an actual addition of 43 per cent. carbonate of magnesia to a limestone would have the effect of increasing its specific gravity nearly one-half, unless we suppose a corresponding expansion of bulk, of which we have not the slightest evidence. We may therefore assume that one atom of carbonate of lime was removed for every atom of carbonate of magnesia added to the rock.

In accounting for the origin of the magnesia, we may either suppose it to have been derived from the magnesian deposits, described as having taken place at an early period of the limestone, and through which all waters from the earth's interior must have risen, in order to reach the higher beds in which these dolomites usually occur; or we may suppose that the same agency which produced the magnesian springs at the former time came again into operation at a later period. The latter is the more probable explanation,—in fact the only one admissible, as we find undoubtedly metamorphic dolomites to occur elsewhere,—as at Howth, for instance,—in what there is every reason to believe are the very lowest beds of the limestone.

Period at which this Dolomitization took place.—We cannot for a moment imagine that the magnesian waters produced no other effects than a slight local conversion of the limestone in the immediate neighbourhood of the cracks and fissures through which they passed.

It is only reasonable to believe that they found their way to the surface, and must there have produced important modifications of the deposits then taking place. Let us see how far this has been the case, and it may perhaps enable us to fix with some degree of probability the period of the dolomitization of these limestones.

We have already seen that the very highest beds of the carboniferous limestone, or those immediately under the coal-measures, have undergone this process. It must, therefore, have taken place after the close of the limestone period. This brings us to the time of the coal-measures, and in these we find no indication of magnesia having found its way in any quantity to the surface. If it had, large magnesian deposits would have undoubtedly been formed. It is not until we have reached the commencement of the new red sandstone, or permian period, that we have any evidence of large deposits of carbonate of magnesia having taken place. *We are thus led to look upon the magnesian conglomerates and limestones, so frequently forming the base of that series, as in all probability produced by those same springs of carbonate of magnesia, which, in their passage upwards, effected that alteration of the limestones which has been engaging our attention.*

This view is rendered additionally probable when we consider that a period of great disturbance had just closed; and through the cracks and dislocations then produced the magnesia in all likelihood found its way.

That it should have penetrated through the entire thickness of the coal measures, is not at all surprising, when we take into account the number of faults by which they are cut up in every part of the British Islands. It is at first sight somewhat strange that it should have produced no corresponding alteration on these strata. This, however, may be accounted for by the fact, that they contain scarcely any limestone, and are made up for the most part of shales and grits, having no sort of chemical affinity for the magnesia. We may presume that the latter must have risen through the old red sandstone as well, yet nowhere do we find any trace of its passage.

If the view here presented be correct,—if there is really a connexion between the carboniferous dolomite and the magnesian rocks at the base of the new red sandstone,—we should expect to find the former occurring abundantly towards the northern and central parts of England, where the new red magnesian deposits seem to have attained their maximum development. Accordingly, we do find that such rocks form an extensive feature of the carboniferous limestone of those districts. Professor Phillips has shown that dolomitic rocks, precisely similar to those we have been describing, abound in

the neighbourhood of Kettlewell, in Yorkshire,* and I believe they are frequent in Derbyshire also, but have not any authority as to this point within reach. This fact serves to confirm the view here taken, that the dolomitization of the carboniferous limestones, and the magnesian deposits of the new red sandstone, were produced by the same outburst of magnesian matter, and at the same geological era.

We might proceed to show that the disturbances and dislocations of the Kilkenny limestone, which prepared the way for the formation of the dolomite, were produced during the upheaval of the slaty tract in the south-west of Kilkenny, the slates of Slieve-na-man, and the Galtees, but this would be wandering beyond the limits of the present notice.

There is one consideration suggested by the facts above described, which should not be overlooked. It is this: where magnesia has produced such extensive results in its passage through limestones, we cannot suppose that other rocks altogether escaped. If, as before observed, we do not find any signs of its passage in the coal-measures or old red sandstone, it may be because these have not been sufficiently examined with a view to this particular point. But

* See "Mountain Limestone District," page 26. The short notice given by Professor Phillips of these dolomites is quite enough to identify them with those of Kilkenny, already described. We give it in full.

"The limestome in the country about Kettlewell is often liable to a local change into a crystallized yellowish or brown dolomitic rock, full of ramifications and nodules, and hollow cells of calcareous spar. The beds and joints in this dun lime, for so it is called by the workmen, are very irregular, and the rock feels heavy. Altogether, it resembles not a little the brown dolomitic rock of Gerolstein, in the Eifel. It is known to the miners that this dun lime runs in lines north and south, destroying the productiveness of the veins through the whole mass of limestone. The courses of this metamorphic limestone are from a few feet to twenty or thirty fathoms in width. They are usually defined by a joint, pass down through all the beds, and sometimes produce pipe or belly veins of lead, which go horizontally between the neighbouring beds, but never enter the dun lime beds; these, in such cases, form a check to the metallic matters.

"These dun 'courses' are said to throw the veins which run east and west four or five fathoms laterally."

We may gather from the last remark that the cracks or faults along which the dolomitization took place were newer than the east and west veins, which of course could not have been formed till after the consolidation of the limestone. This corroborates our hypothesis.

there are appearances often presented by granite (for instance where it suddenly becomes talcose or steatitic along a joint), which would point to an alteration of this kind. Where rocks contained a certain amount of lime and oxide of iron,—and this we know to have been the case with many of the older slates,—there was only wanting a supply of magnesia and the necessary heat to convert them into hornblende schist, or even into greenstone; and it is not difficult to see that granite itself might be changed into greenstone where it came into connexion with these substances. The part which magnesia may have played in such cases well deserves the attention of the theoretic geologist.

Where the composition of the above limestones or dolomites has been specified, it has been derived from a series of analyses made at the Museum of Irish Industry, by Mr. Sullivan, chemist to the Museum.

NOTE.—The only works within reach, in which I find any notice of these rocks, are, Phillips' "Mountain Limestone District of Yorkshire," page 26, as already quoted; "De la Beche's Geological Manual," third edition, page 475, and after, where the mode of occurrence of the dolomites of northern Italy is described, and a condensed account given of Von Buch's researches and conclusions. The metamorphic dolomites of Kilkenny have been treated of by Mr. Griffith in his "Geological and Mining Survey of the Leinster Coal District," page 9, under the name of brown spar rock or sidero-calcite, and their anomalous character pointed out. In the Journal of our Society there are some papers on the subject, but mostly occupied with the chemical question.

April 12, 1854.—"On the Iron Ores of Carnarvonshire;" by the Rev. Professor HAUGHTON.

HAVING had an opportunity recently of examining and analyzing the principal iron ores of Carnarvon, I thought that the results would be of some interest to the Geological Society of Dublin. I have therefore prepared a short abstract of the results of my observations.

1. The first quarry of iron ore examined by me is situated near Bettws Garmon, on the road from Carnarvon to Beddgelert. It is worked by the Aberdare Iron Company, and the iron ore extracted

from it is shipped to South Wales, to be mixed with the clay ironstones, which are not so rich in per-centage of iron. The ore is of a dark-green colour, oolitic texture, and is magnetic. The iron occurs in it in the form of protoxide and peroxide; some of the former being combined with the latter as magnetic oxide, and some being combined with carbonic acid. This ore is found stratified conformably to the bedding of the black slates in which it occurs. It is found in a single bed of a thickness varying from 25 to 32 feet; strike bearing E. 50° N. and dip 50° S. E. The outcrop of the bed is parallel to the line of junction of the black slates and roofing slates, this junction being somewhat less than half a mile distant to the N. W.

Its geological position is therefore the lower portion of the lingula beds, and I believe no fossils have been found beneath it.

The following analysis, made by Dr. Price, of Newport, will give a better idea than a long description of the exact nature of this interesting ore.

1. *Oolitic Magnetic Iron Ore, Careg Fawr.*

Loss by ignition (being Carbonic Acid, Organic Matter, &c.),	7·90
Clay and Silica,	12·90
Peroxide of Iron,	34·14
Protoxide of Iron,	32·90
Alumina,	3·66
Lime,	5·00
Magnesia,	1·00
Phosphoric Acid,	2·25
Sulphur,	0·25
Arsenic,	Trace.
	100·00

The quantity of metallic iron is 49·50 per cent. in the raw ore, and 53·74 per cent. in the roasted.

2. A bed of iron ore, resembling that just described, occurs on the west coast beyond Clynnog, near Morfa, at the foot of Yr Eifl. It is, however, composed of coarser globules, and might be described as pisolitic rather than oolitic. It is also of a redder colour, and more variable composition; the most remarkable difference occurring in the quantity of phosphoric acid, which is so very great in some

specimens as to warrant the inference that it occurs in nodules irregularly distributed.

The following Table gives the results of trials made on seven specimens:—

Pisolitic Iron Ore, Llanaelhaiarn.

	1	2	3	4	5	6	7
Loss by ignition,	19·23	14·00	. . .	17·89			
Clay and Silica,	. . .	. . .	14·72	11·28			
Peroxide of Iron,	. . .	. . .	*55·34	25·29			
Protoxide of Iron,	. . .	. . .	. . .	33·24	11·13		
Alumina, . . .	. . .	. . .	†4·83	†7·09			
Lime, ...	. . .	. . .	‡1·85				
Magnesia, . . .	. . .	. . .	Trace.				
Phosphoric Acid,	. . .	. . .	. . .	. . .	. . .	10·38	1·32

The average composition of this ore would therefore be:—

2. *Pisolitic Magnetic Iron Ore, Llanaelhaiarn.*

Loss by ignition, ...	18·61
Clay and Silica, ...	13·00
Peroxide of Iron, ...	25·29
Protoxide of Iron, ...	33·24
Alumina, ...	§7·09
Lime, ...	1·85
Phosphoric Acid, ...	1·32
	100·40

This gives of metallic iron 43·55 per cent. in the raw ore, and 53·50 per cent. in the roasted.

The bed in which this pisolitic magnetic iron ore occurs has an average width of 18 feet, and is conformable to the bedding of the black slate in which it lies, its strike bearing E. 35° N. and dip 80° N.

Besides the pisolitic ore just described, two other varieties occur in the same bed,—the first being found near the walls of the lode, and the other appearing to constitute large nodules of a fine oolitic texture and reddish colour.

* Including phosphoric acid, &c., and without separating protoxide of iron.

† Including phosphoric acid.

‡ Not in combination with phosphoric acid.

§ Containing some phosphoric acid.

3. *Black Slaty Iron Ore, Llanaelhaiarn.*

Loss by ignition (being Organic Matter and Water),	8·13
Clay and Silica,	38·79
*Peroxide of Iron,	40·34
Alumina,	12·55
Lime,	Trace.
Magnesia,	0·31
Phosphoric Acid,	0·07
	100·19

4. *Kidney Iron Ore, Llanaelhaiarn.*

Loss by ignition,	28·03
Clay and Silica,	2·62
Peroxide of Iron,	5·92
Protoxide of Iron,	49·92
Alumina,	3·12
Lime,	5·87
Magnesia,	Trace.
Phosphoric Acid,	4·45
	99·93

Metallic iron = 42·95 per cent. in the raw ore, and = 59·66 per cent. in the roasted ore.

This kidney ore contains a much larger proportion of protoxide than usual, and appears to be simply a nodule of spathose ore, with a considerable quantity of phosphoric acid. The different parts of the lode are very variably magnetic, according as the magnetic oxide or spathose iron predominates.

3. Several beds of magnetic oolitic iron ore occur about a mile beyond Abersoch, St. Tudwal's Road,—the ore resembles in many respects the oolitic ore of Careg Fawr, but occasionally passes into a reddish coarse-grained ore, resembling some of the varieties from Llanaelhaiarn. These beds conform to the bedding of the slate in Mr. Homfrey's mine, where they have a strike of E. 25° N. dip 60° N., and average width of 25 feet. Two or three of these beds are exposed in this quarry, one of them containing a large "horse" or nodule of shale in the centre of the iron ore.

The beds of black slate are very much disturbed in this locality, and the beds of iron ore appear to have been broken and twisted with the slates in which they occur.

* Protoxide included.

At Holland's quarry, at Vron, the strike is N. 60° E.; dip S. E. nearly vertical, and width of bed, 18 feet.

The average strike in the Abersoch district is between E. 25° N. and E. 70° N.

The following analysis shows the composition of the black oolitic variety of ore.

5. *Black Oolitic Iron Ore, Abersoch.*

	1	2	3	Average Comp.
Loss by ignition, .	19·01	18·97	. . . .	18·99
Clay and Silica, .	22·49	22·57	22·78	22·61
Peroxide of Iron, .	. . . .	. . . .	4·04	4·04
Protoxide of Iron,	. . . .	. . . .	44·01	44·01
Alumina, ...	. . . .	*9·13	*7·60	5·74
Lime, ...	. . . .	1·57	. . . .	1·57
Magnesia, . . .	. . . .	1·21	. . . .	1·21
Phosphoric Acid, .	1·86	. . . .	. . . .	1·86
				100·03

Giving of metallic iron 37·06 per cent. in the raw ore, and 45·75 per cent. in the roasted ore.

The large quantity of phosphoric acid occurring in these ores diminishes their market value, as it injures the iron produced from them. How to account for the phosphoric acid is a difficult question, and in expressing my own opinion that it is due to organic remains, such as coprolites, &c., I merely offer a conjecture to account for the presence of the phosphoric acid by known causes. If this be the true origin of the phosphoric acid, its occurrence is very interesting, as the geological position of the beds of ore is below the oldest beds in which fossils have hitherto been found.

Another very interesting question suggests itself from the examination of the facts described,—Are these deposits of iron ore lodes or beds? They appear to conform accurately to the bedding of the slate at Careg Fawr, for a distance of more than three-quarters of a mile; and at Llanaelhaiarn and Abersoch there is no possibility of detecting any deviation from the bedding of the black

* Including phosphoric acid.

slates. If, therefore, they are lodes, they must have been formed in fissures, made along the planes of mechanical deposition of the black slates; but this appears to me so improbable that I prefer considering them as beds formed by chemical action at the time of deposition of the slates in which they are found. All the deposits of iron ore occur in the same geological horizon, and there must have been some very unusual combination of causes to produce simultaneously over so great an area the large amount of iron ore which we now find there.

The mode in which these deposits occur is very similar to the mode of occurrence of the pyrites courses of Ballymurtagh, which have been generally considered as deposited conformably to and simultaneously with the slates in which they occur; and it must be confessed that there is some difficulty in supposing the fissuring of beds in the direction of their bedding. But it is possible, as Mr. Warrington Smyth has endeavoured to show in the Ovoca mines, that there may be a tendency to cut very obliquely across the line of strike, and that the conformability may be only true within a certain distance.

The short depth to which the ironstone beds have been worked in Carnarvonshire renders it difficult to determine this point with certainty.

April 12, 1854.—"On the Drift of the District about Rathfarnham, in the County of Dublin;" by John Kelly, Esq.

The district which I have selected for the subject of this evening's paper is that part of the county of Dublin which lies south of the river Dodder, about Rathfarnham, which, from the form of the ground and the nature of the underlying rock, appeared to me to be an eligible locality for the purpose of studying the transported gravel, or drift.

It comprises an area of about twenty square miles—that is, from Glenismaule on the west to Dundrum on the east, six miles; and from the Dodder, in the vicinity of Rathfarnham, on the north, to the mountain brow on the south, three and a half miles.

The mountains of the county of Dublin, on the north side, pre-

sent a steep face, having a few bold bluffs or hills projecting into the low ground towards the river Dodder, those bluffs being separated from each other by rather deep valleys. The hills in the district under consideration are Montpelier Hill, or, as it is sometimes called, the Hunting-house Hill, Tibradden Mountain, Kilmashogue Mountain, and the Three-Rock Mountain.

The valleys are, first, the valley of the Dodder, or Glenismaule; second, that in which lies Killikee demesne; third, the valley south of Laurel Hill, between Tibradden Mountain and Kilmashogue Mountain; and fourth, the valley of Ticknock. In each of these valleys the subjacent rock is chiefly granite, while the diluvial matter is all limestone gravel.

In order to make some of the facts I am about to describe more available for reference, I shall number them in paragraphs as I proceed.

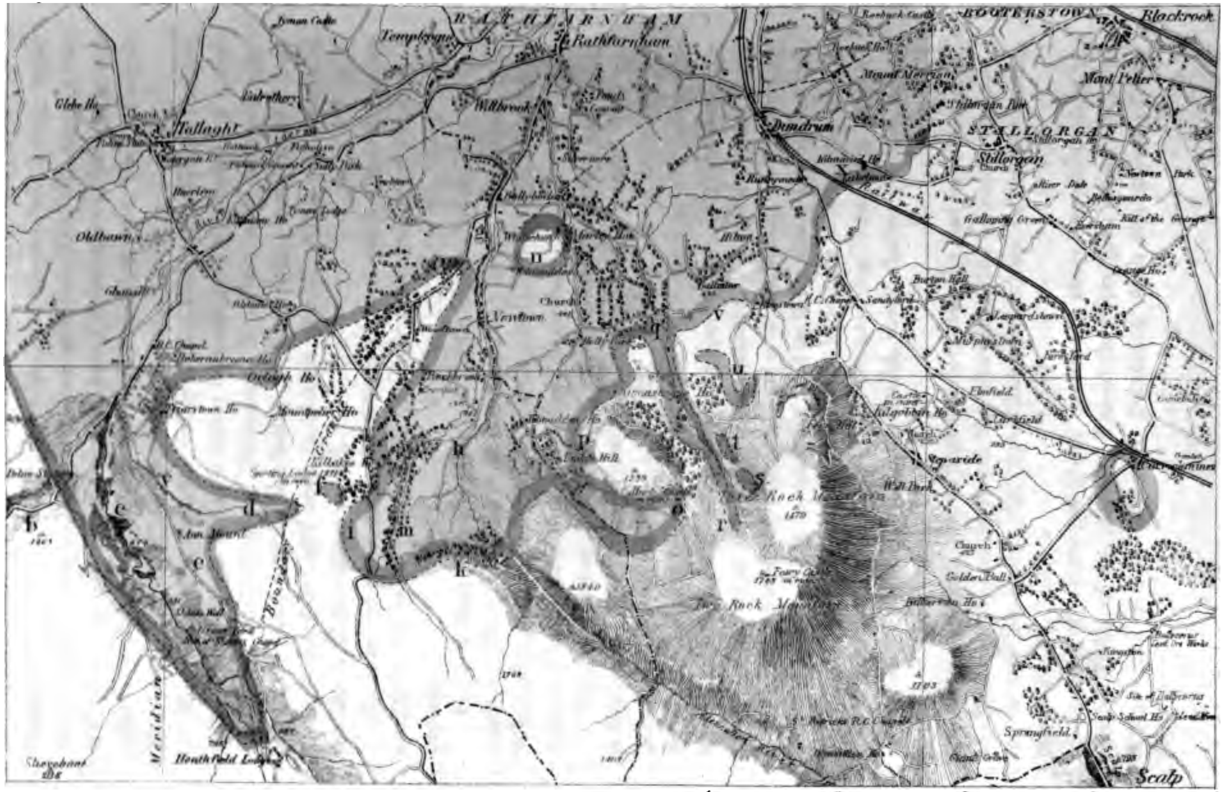
I give a map, which is a part of the Ordnance Index Map of the county of Dublin. The drift is coloured on it with a neutral tint. Where there is no drift it is left white, and there are small letters of reference to the localities of the facts described.

The Members of this Society are aware, that as a general rule it is found that the gravel of a district of country is formed of fragments of the rock which lies beneath. Thus in slaty districts the debris or gravel is formed of small pieces of slate, mixed with the same material ground down to a very fine state. In granite countries the gravel is composed of fragments of granite mixed with sand, or sometimes the rock itself in a decomposing state forming a coarse sand. This is common in the hills above Rathfarnham, and the sand is called freestone. In limestone tracts, the native gravel has usually a clayey matrix containing numerous pebbles and boulders of limestone, mixed with black shales, ground down to very small fragments.

1. It is a peculiarity of this district, that the underlying rock is composed of one material, and the diluvial matter of another, showing to a certainty that the gravel has been drifted or removed from one place to another.

In each of the valleys above mentioned there are differences in the condition of the gravel. I shall therefore give a short outline of that condition in each case, beginning with the valley of the Dodder.

MAP of the DRIFT DISTRICT near RATHFARNHAM,



Scale of Statute Miles.
1 2 3 4 5

2. The river Dodder, near its source, takes a north-westerly direction; then turns north to Bohernabrena, whence it gradually turns round by Oldbawn and Rathfarnham to a north-east course, which it pursues till it joins the Liffey at Irishtown. In the upper part of its course the stream tumbles over a succession of small falls on granite rock, till it comes to a height of about 670 feet above the level of the sea, where it leaves the rock, and enters a bed of gravel at Cunard (see Map, *a*), at the upper end of Glenismaule. From this the river continues its course, in a thick bed of the same gravel, or drift, by Rathfarnham and Donnybrook, to its termination at Irishtown.

3. I give a section made from the Ordnance Map of the County of Dublin across the valley of Glenismaule. It is on a line drawn from the top of the hill of Slievenabawnoge (see Map, *b*) to a trigonometrical point on Glassamucky, about a mile distant to the east (see Fig. 2).

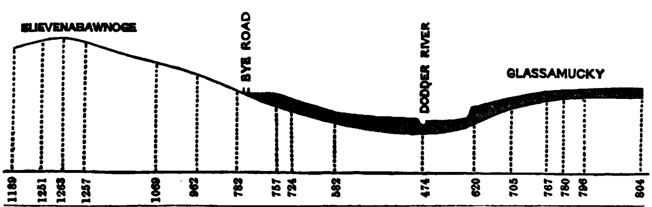


Fig. 1.—Section across Glenismaule.

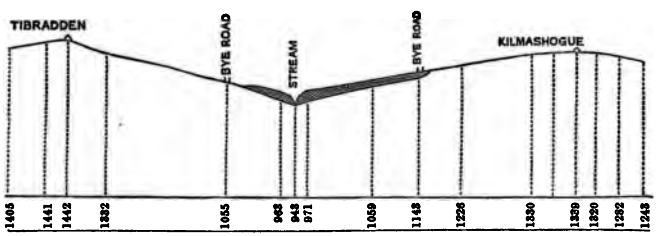


Fig. 2.—Section, across the Valley, between Tibradden Mountain and Kilmashogue Mountain.

In the several sections the scales are the same for length and height, being three inches to a mile, or 1760 feet to an inch. The part at the surface in these cuts, engraved with diagonal tint, represents the limestone gravel.

4. The height over the level of the sea, marked for the surface water in the Dodder, in the line of section is 474 feet; and the bank on the east side, at *c* on Map, about 700 feet: the difference, 226 feet, may be taken as the thickness of the mass of gravel at this place, at least, since nothing but gravel is visible in the eastern steep bank.

5. In the Dodder at Cunard, at *a* on Map, where the stream first enters the gravel, the section is peculiar (see Fig. 3).

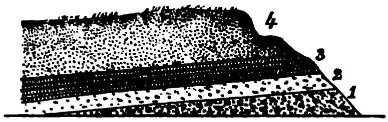


Fig. 3.—Sectional View of Gravel Bank at Cunard.

1. The lower layer visible is a cohesive bluish clay, with small boulders of limestone, rounded, or limestone gravel,	12	feet.
2. Bluish sandy clay,	10	„
3. Brown sandy clay and brown sand alternating in thin layers,	15	„
4. Whitish sand, of decomposed granite, about	40	„
Total,	77	

6. As before stated, the highest level at which the gravel is found in the bed of the river in Glenismaule is about 670 feet; yet lower down in the glen it is found in the line of the section on the west side of the river, and a few perches from it on the hill-side at 780 feet high; and on the east side it is continuous from the Dodder, up on the slope of Montpelier Hill, to a height of about 1100 feet. Large banks of it occur at this place, in Piperstown, at *d* on Map, at about 1000 feet above sea level, which in that locality appears to be about 100 feet in thickness. Thus the gravel lies at a higher level on the east side of the valley of the Dodder than on the west, by about 320 feet.

7. The limestone gravel of this district, and generally of Ireland, is of two kinds, very distinct in appearance—the corn gravel, and the loose pebbly gravel, or, as it is called in some places, road gravel. The corn gravel is very strong and cohesive: it has a matrix of bluish-gray clay, which contains masses of limestone, generally rounded, and small, but sometimes angular, and sometimes

large. Where excavated, it stands in banks nearly perpendicular. It is frequently used as manure by the farmers—hence its name, corn gravel. It generally lies lowest, next the rock.

8. The loose gravel, or, as it is sometimes called, road gravel, is altogether composed of clean-washed sand and rounded pebbles, having little or no clay: it usually lies in layers, which are sometimes thick, sometimes very thin; some of the layers being of coarse material, and some of fine sand. From this disposition in layers it has a stratified appearance. The escars are composed of it, and also many low gravel hills. It generally lies uppermost, or over the corn gravel.

Both kinds of gravel occur in this district. Good examples of the first are found in several places in the banks of the Dodder, in the vicinity of Rathfarnham, at Templeogue, and in Glenismaule, where it is seen at the east side of the river, in banks above 100 feet high. The second kind, or loose gravel, is well exhibited in a large gravel-pit near Mr. Cobb's lodge, at Glassamucky, to the east of Glenismaule, where about 30 feet in thickness of it is seen (see Fig. 4).

Fig. 4.

8. On the top of Montpelier Hill stands an old building called the Hunting-house, a conspicuous object from the low country round Dublin for many miles. Its height is 1271 feet above sea level. About forty perches to the south-east of this summit is a

gravel-pit, situated in the middle of a detached piece of limestone gravel of six or seven acres (see *f* on Map). It is a little to the south of and lower than the summit of the Hill, standing as it does between 1170 and 1240 feet in height. The greatest depth of the gravel appears to be at the pit, and is about 20 feet. This old pit was excavated in the patch of limestone gravel, probably to get sand for building Killikee House, which is convenient. There is a rabbit burrow in this pit, in which, as might be expected, the stuff thrown out by the little animals is fine limestone gravel and sand. That the gravel does not extend over the mountain, which is pasture, is proved by another rabbit burrow, about a quarter of a mile to the south-west from this one. In this latter the stuff thrown up is decomposed granite, without a single pebble of limestone, and this appears to be the general substratum of the soil. A remarkable fact here is, that to the south of this patch of gravel there is a low hollow, or pass, running east and west between this hill and another lying south of the pass, which appears to contain no limestone gravel, and it is 190 feet lower than the pit in the gravelly deposit near the top of the hill.

9. The second, or Killikee valley, contains a vast quantity of limestone gravel. Several thousand acres of it occur in Killikee demesne, and continuous down the valley towards Rathfarnham, and in some places it is of great thickness. In the west bank of the stream, opposite the village of Ballyedmond, it is visible about forty feet thick at *g* on Map. Near the old graveyard of Cruagh, the top of the bank, near Killikee gate, stands at 630 feet above the level of the sea. The stream, at a little bridge opposite, in which the granite rock occurs, is 554 feet, thus giving a height or thickness of 76 feet of gravel at this place. See *h* on Map.

10. The upper edge of the gravel deposit of this valley, in the vicinity of Killikee demesne, stands at about 1240 feet above sea level, along its southern margin, from *i* to *k* on Map; and it falls from this towards the Dodder at Rathfarnham, where it is about 140 feet; thus covering continuously a slope four and a half miles long, and found at every height within the above range of 1100 feet.

The upper edge of the gravel near Killikee demesne, as was said before, stands at about 1240 feet high, and its upper margin keeps this height along its western and southern boundary very regularly in this valley; but its eastern boundary, which lies on the N. W.

slope of Tibradden Hill, descends gradually from 1200 to 800 feet, which is its height opposite Larch Hill House, adjoining the freestone pits. See *l* on Map.

11. At Newtown, a mile and a half south of Rathfarnham, on the roadside, is a good sectional view of the gravel hereabouts, at *g* on map. A view of it is given (Fig. 5). Here the gravel consists of two distinct layers, the lower about 20 feet thick, of fine brownish, sandy clay, with a few small stones of limestone; the upper layer, about 20 feet thick also, of clayey gravel, with boulders of limestone, rather numerous, sometimes roundish, sometimes angular, and often a foot in length. The stones and gravel of the upper layer are quite distinct in appearance from the lower, with a well-defined line between them, clearly showing two distinct deposits.

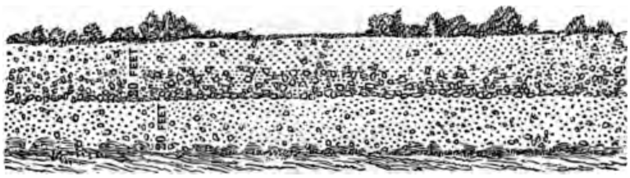


Fig. 5.—Sectional View of Gravel Bank at Newtown.

The gravel in this bank at Newtown is all of the strong or cohesive kind, in both layers. In this valley the loose gravel occurs also, higher up, at the east side, in the townland of Cruagh, at *m* on Map, where two pits have been made in it, for sand and gravel for the roads. This is similar to the gravel of the Glassamucky pit, near Mr. Cobb's lodge, before alluded to.

12. In the upper part of the deposit, next the mountain, the limestone gravel is often covered over with a layer of other gravel, which is composed of sand, with fragments of granite and slate, and contains no limestone pebbles.

13. There is a particular fact in this valley well worthy of attention, see *n* on Map. It is a spot without any gravel. The graveyard of Whitechurch, two miles south of Rathfarnham, is on the east margin of it. It occupies about forty acres. Here the granite rock appears at the surface, and has none of this gravel over it, although it is surrounded by it on every side; and at Newtown, only two fields off, it is 40 feet thick, as before stated. This might

be considered to be a patch standing on a higher level than the surrounding land, but it is not so. The accompanying section (Fig. 6), taken from the Ordnance Map, is made on a line running N.W. from Taney Church through the place, and shows that this part without gravel is not on a higher level than the average of the neighbouring ground.

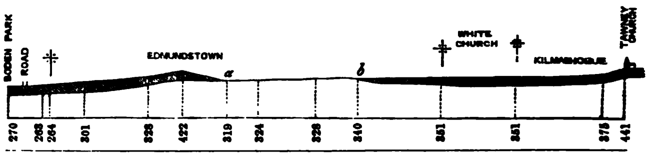


Fig. 6.—Section, from Taney Church, North-westwards, through Edmondstown.

Scale of length and height the same, 1760 feet to an inch.

Here the space, *a*, *b*, is that in which no gravel occurs over the granite rock.

THIRD VALLEY.

14. This valley lies between Tibradden Mountain and Kilmashogue Mountain, and, though a small one, exhibits some facts worthy of notice.

In the ascent southward from Laurel Hill, which is near the entrance to this glen, the gravel deposit continues for about two-thirds of the way up; at this place the band takes a turn eastward, up the slope of the mountain, to the top of the ridge at Calbeck Castle, where it terminates at about 1300 feet above the level of the sea, at *o* on Map. This is the greatest height at which I found limestone gravel in the district.

15. The termination of the gravel at Calbeck Castle, though on the summit of the mountain ridge at this place, is on a low part of the ridge or pass which divides this valley from Ticknock. It is about 60 feet lower than the summit of Kilmashogue Hill, which is 1339 feet high, and lies northward about 100 perches off.

16. Though the mountain east from Larch Hill is from 1000 to 1200 feet high, no gravel rests on its side adjacent to this little demesne, at *p* on Map, above 800 feet; yet higher up in the valley, on the east side, at Calbeck Castle, it attains 1300 feet, as was said

before, and its upper margin, along the side of Kilmashogue Hill, rises gradually, this difference of 500 feet in a mile distance.

17. The gravel on the east side of this valley lies on higher ground than it does on the west side opposite, by about 200 feet. The section (Fig. 2) shows this fact; and this is independently of the band running up to Calbeck Castle, which has no counterpart on the west side.

18. In a gravel pit, 60 perches south of Calbeck Castle, near an old limekiln, at *o* on Map, there are some appearances worthy of note, inasmuch as I shall have reference to them in a subsequent part of this paper.

The accompanying sketch Fig. 7 represents the successive beds or layers of gravel, which are of different materials.

Fig. 7.—Sectional View, 15 Chains South of Calbeck Castle.

No. 1. The lower layer visible at this place is about four feet in thickness; it is composed of bluish-gray, cohesive clay, without pebbles.

No. 2. The second layer or bed is three feet thick, of clean gravel and sand, with small pebbles of limestone, from one to two inches diameter, intermixed with larger pieces of granite, of from three to nine inches in diameter.

No. 3 is of irregular thickness, between two and three feet; it is composed of thin layers of fine brown clay, alternating with other thin layers having a little sand. In this bed the thin layers are very much contorted, but in a great degree preserving their parallelism.

The disturbance which occasioned the contortion was violent; for no layers deposited in water, in the ordinary way, could have the appearance presented here, the original conformity of the thin layers being broken, both on the upper and lower surface of the bed, from parts of them having been removed. Besides this, there is another unconformity in the layers, as if the floe from which the materials were deposited had got a move when half its deposit had been laid down, which disturbed the layers already deposited; and after this disturbance it continued to let down new layers unconformably on the ends of the old ones. The drawing will explain this better than description.

No. 4 is about one foot thick, composed, like No. 2, of limestone, gravel, and sand, with pebbles of limestone and granite; but in this the pebbles are smaller, being under two inches diameter.

No. 5 is the upper brown, fine soil, from three to nine inches thick, which produces coarse grasses and heath, the pasture of the mountain.

THE FOURTH, OR TICKNOCK VALLEY.

19. This lies between Kilmashogue Mountain and Three-Rock Mountain: in it the rock is all granite, which, in the upper or southern part, is mostly at the surface, in a decomposing state, and numerous pits are dug in it to get a supply of freestone for the Dublin market. The quantity of gravel in this valley is comparatively small, but it occurs in a peculiar and remarkable manner. From the limestone gravel in the low grounds about Marlay, a narrow tongue runs southward about a mile and a half, on Map from *q* to *r*, and varies in breadth from ten to eighty perches; the height of this tongue is 400 feet at the north end, and rises to 1000 feet at the upper or south end. Besides this, there are two detached patches of gravel, of oval form, on the east side of the valley, in the townland of Ticknock. The upper, or southern one of those, *s* on Map, is about ten acres in extent, stands between 1000 and 1100 feet high, is ten feet thick, and lies on the hill side or slope, its upper edge being much higher than the lower. The second patch is about four acres in area, *t* on Map, stands at about 700 feet high, and is two to three feet thick. The gravel in both patches, and in the tongue, contains pebbles of limestone, and pieces of black, carboniferous slate, mixed with bluish clay and sand.

20. Another detached piece of this gravel occurs farther north, in Ticknock also, at 620 feet in height. It is half a mile long, but forms a long, narrow, crooked band, nearly in the shape of the letter S inverted, *u* on Map. It occupies an area of about twenty acres, and is of irregular thickness, under ten feet.

21. To the east of this valley, except the three patches just described, there is no limestone gravel on the northern face of Three-Rock Mountain at a greater height than 300 to 400 feet, this being the range of its upper margin at Ballally and Taylor's Grange, two miles south of Dundrum, at *v* to *w* on Map.

22. All the gravel on the hill tops and slopes in this district, above the level of 1300 feet, is local, and formed chiefly from pebbles of granite, mixed with sand, which is also derived from that rock; and near the upper edges of the drift there is a proportion of this local gravel mixed with the transported gravel.

23. On the border of this district, the village of Carrickmines is situated in the bottom of the valley lying between the Three-Rock Mountain and Killiney Hill. To the east of this valley the slope is covered with limestone gravel, from 230 to 320 feet in height; while immediately west of the village, and in the lowest channel of this great valley, the granite rock is bare, and there is no gravel found, even so low as 240 feet, that is, 80 feet lower than on the east side.

24. The highest elevations at which I have observed limestone gravel in the district are at Montpelier Hill, where it lies 1240 feet above the level of the sea; along the southern side of Killikee demesne it reaches 1240 feet for more than a mile continuously; and at Calbeck Castle, where it reaches 1300 feet.

25. At the new railroad bridge over the Dodder, near Dundrum, the bearing or covering of the limestone quarry is composed of three layers. The lowest is a layer of dark gray, strong, clayey gravel, 15 feet thick, limestone pebbles forming about one-thirtieth of the mass; the second layer is 6 feet thick, in alternate sandy and fine clayey laminæ, of a dark yellowish-brown colour, without any pebbles; the third is composed of brown, friable gravel, 8 feet thick, with a few pebbles of limestone; over this is one foot thick of vegetable mould.

26. At Rathgar the drift or bearing of the quarry is irregular, but mostly composed of two layers. The lower is a strong, yellow-

ish, cohesive, clayey gravel, 6 feet thick, and has limestone boulders, some a foot in length, which make up one-tenth of the mass; the upper, a brown, friable loam, 6 feet thick, having very few fragments of limestone, but numerous pieces of black shale. On top of the latter is the usual layer of one to two feet thick of vegetable mould.

27. On the low ground, near Dundrum, in the railroad cutting, *x* on Map, there appears no broken-up granite, or, if I may so call it, native gravel, on the granite rock. All the pits and hollows formed by the irregular surface of the rock are filled with transported gravel, formed of the *debris* of limestone and black shale, rounded, and ground down very fine, apparently by attrition in water.

28. Marine shells I have not been fortunate in finding in quantity in the limestone drift of this district. I got some fragments, however, a little to the east of Glenismaule, in the south end of the little townland of Corrageen, about 600 feet above sea level, *y* on Map. They occur in a layer of coarse sand, in a steep bank, about ten yards east of the road, opposite a little bridge. I found several obscure fragments, but some had the striæ apparently of *Mactra solida*, and one small specimen, nearly complete, of *Turritella terebra*.

29. I may observe that, in places beyond the boundaries of this district, limestone gravel occurs on Silurian grits and slates, on the western slopes of the hills near Dunlavin, in the county of Kildare, as high as 800 feet; and on the western slopes, also, of the Slievebloom Mountains, near Kinnitty, in the King's County, on similar rocks, at a height of from 800 to 900 feet. It exists in considerable quantity in the valley of the Barrow, between Bagenalstown and Athy. At Kildare a well for a pump was sunk in it to the depth of 98 feet, without meeting the rock; and it occurs in great quantity in many other places.

I have thus shown that, in this district, drifted, or transported gravel, derived from carboniferous rocks, is found resting on granite, at every height, varying from 100 to 1300 feet above the level of the sea: that it occurs in detached patches at the height of 1000 feet and upwards in some places, lying on the sides of the hills: that there is one patch so low as 330 feet, which has not any of this gravel, although surrounded by it on every side: that extensive areas are covered with it, on the slopes of the mountains, at heights

varying from 300 to 1300 feet; and that extensive areas on the same range, on similar slopes, have no gravel higher than between 300 and 400 feet.

I have thus described the gravel of this district as well as I could at all its varied elevations, with a view to try to establish a standard founded on local facts, to which the drifts in other districts may be compared.

I shall not at present enter into any more descriptions of particular facts, and will now offer a few theoretical considerations as to how this gravel was transported, which I would not venture on only that I think it a duty that any writer of a paper, who has examined his subject, should state his views of the phenomena he has himself observed, and lay before the Society the conclusions at which he has arrived.

One of the most able writers on geology of our times, Mr. Phillips, says: "For many and obvious reasons, it is desirable that the task of combining local truths, the first order of inferences in geology, should be attempted by the same person who has ascertained them. To him gradations and variations are often known, too minute for description, yet necessary to the train of argument, and influencing rightly his own conviction; the relative value of the observations has due weight with him in clearing up discrepancies and correcting results; and thus data are made available which would be too incomplete, or apparently disagreeing, for other men to employ with safety. Besides, it happens in geology, as in other sciences, that few persons but the observer will be at the trouble of the necessary discussions."

My views, then, are—

1. That the surface of the land has not been altered since the gravel was transported and distributed in this district, that is, that hill and valley have continued the same, or very nearly the same shape, at the time of the deposition of the gravel, and at the present time.

2. That the gravel was transported, partly by the agency of violent currents of water, flowing from the west or north-west; but as I shall endeavour to show, that water alone was not sufficient for the purpose.

3. That the agency of ice was, along with currents of water, also necessary for the explanation of facts regarding the drift, as

detached in a spot of six or seven acres on the brow of a hill: all the slope round, at and under the same level, would be equally covered, which it is not.

Another fact, nearly of a similar kind, is stated at paragraph 19. A spot of limestone gravel of ten acres lies at the east end of Ticknock valley, between 1000 and 1100 feet high. At this place the east side of the valley is a steep slope, and the upper edge of the gravel is 100 feet higher than the lower; the whole quite detached, and lying on decomposing granite. It appears to me that this spot of gravel could not have been deposited in a great current of water, on the steep side of a mountain, at 1000 feet high, while the lower land adjoining, down to the stream, a few perches off, has not any of it.

Again, it is stated at paragraph 23, that at Carrickmines gravel covers the east slope of the valley from 230 to 310 feet above the sea, while on the west slope the granite rock is bare, and there is no gravel on it even so low as 240 feet. This village is situated in the lowest part of this wide valley, and it appears that if the gravel were transported here by a current of water alone, without other agency, the valley should have been filled up with gravel from side to side, on the same level, which is not the case.

A careful consideration of the facts just enumerated leads to the conclusion that currents of water alone could not have been the medium by which the limestone gravel was transported and distributed in the district; but currents of water, along with floes of ice, loaded with gravel or drift, are sufficient to account for all the phenomena connected with the subject.

The land having been in its present condition as to hill and valley, and the gravel formed, that is, brought to pebbles, sand, or mud, and spread out over the great limestone field lying in the midland counties of Ireland, between Dublin and Galway, where most of the bogs now exist,—I believe this field to have been the chief source whence the drift of our district has been derived, and brought by a current coming from the west or north-west, in which direction the rock abounds, and the gravel also. I assume that at that time drainage was imperfect, and shallow lakes existed in depressions of the surface, having much of this gravel in their bottoms and margins; that an extreme hard frost set in; that those lakes were frozen quite through, and that all the gravel in their beds and

margins was frozen into one mass along with the ice; that a great wave from the Atlantic flowed over the land; that the mass of ice which previously constituted the lake was floated in the water, with its freight of gravel, and carried away eastward in the current, and that all the lakes in the land were similarly converted into ice floes, loaded, some with gravel, some with sand, some with mud, and floated on the surface of the water, like ships into a harbour; that the water rose at that time to the height of about 1300 feet above the present level of the sea; that the tops of the Dublin and Wicklow mountains, above that height, were not under water, but formed an island, or barrier, which threw the current chiefly northward over the low parts of Dublin and Meath counties; that in this condition, in the Rathfarnham district, Montpelier Hill and Kilmashogue Mountain would have projected as headlands into the water, and the valleys of Glenismaule, Killikee, Tibradden, and Ticknock, would have been bays or recesses on the southern shore; that many of those ice floes would have been driven at the highest water, perhaps, assisted by a north wind, against the northern face of the Dublin Mountains, and grounded or stranded there; others have got entangled in glens or low passes between hills, where the water flowed eastward, but through which the floe, from its size, could not pass. In these recesses such floes would escape being carried eastwards by the current into the Irish Channel or to Wales; that after this the waters receded gradually, and the floes grounded and melted, dropping their contents of pebbles, sand, or mud, where they happened to be fixed, whether on the top of a hill, or on its side, or in a pass between two hills, or high up in a valley, as the case might be. In this manner might gravel from any low limestone district be transported to a higher level, and deposited on granite or any other rock, as it is now in the district which forms the subject of our paper this evening.

In many of the preceding paragraphs, especially at Nos. 6, 16, 23, and 28, I have noticed that in those valleys which have a north and south direction, the gravel stands at a higher level on the east side than on the west; and that similar deposits occur over large areas on the slopes rising eastward near Dunlavin, in the county of Kildare, and on the western slopes of the Slievebloom Mountains, near Kinnitty and Shinrone, in the King's County. This I attribute to the floes which contained the gravel having been brought

by a current from the north-west, and, having been carried in a south-east direction, would have struck upon the eastern sides of the valleys, or the western slopes of ridges, cast aground, and fixed there.

But it may be asked, why is it supposed that a current came from the north-west, for such limestone gravel might as well have been brought from Lancashire or Derbyshire, with a current coming from the north-east, and the floes afterwards, when the wave was at its height, by a N. W. wind, blown to the eastern sides of those recesses or valleys. It appears to me that there is a much greater probability that such a wave as would cover the land 1300 feet high would come from the Atlantic Ocean, than from the Irish Sea or the German Ocean, which lie north-east. There appears another reason: the bog basins, or hollows, in which the bogs exist in the midland counties of Ireland, are lower in the centres than round their margins, as if they had been excavated, and the materials carried away. The bottoms or subsoil of those bogs is generally gravelly clay, which corresponds with the lower part of a mass of gravel which had undergone great attrition in water, where the coarser materials would be above, and the finer below. Here, then, we can recognise the excavations from which the gravel and sand were taken; we see innumerable heaps of the gravel and sand itself, and since those excavations appear to have been the chief source for the supply of gravel, and that they lie towards the westwards, it may be presumed that the current that carried the gravel away came from the west or north-west.

Indeed, the amount of drift is much greater towards the eastern side of our island than the west. In the country between Loughrea and Galway Bay there are many hundreds of acres of bare limestone rock, at low levels, without any drift; while in the low parts of the counties of Kildare, Dublin, and Meath, even a small tract of bare rock is the exception. This appears as if the violence of the great waves coming in from Galway Bay tore away the drift, and left the rock bare; and that in its further progress eastward it became more moderate, and deposited some of that drift on the flat district of our midland counties, where the bogs now exist.

It may be asked, what reason I have for supposing that the general form of hill and valley have not been altered since the drift period. To this I reply, that I believe the drift to have been formed

in the bottom of a great current, and its materials not far removed by that current from the parent rock. The great mass of this drift lies in the central limestone plain of our island, between 200 and 400 feet above sea level. The Dublin and Wicklow Mountains stand at 1500 to 2000 feet over the same level, and above 1300 feet they, as a general rule, have no such drift. Had they been on a low level at the time the drift was formed, it would have been spread out over them, and subsequently, when they were elevated, so would the drift on their surfaces have been elevated along with them; but such is not the case. I, therefore, conclude that the land which is high now was high then, and the land which is low now was low at that time, and, therefore, that no great change of feature has taken place since in the surface.

Again, all the circumstances connected with the drift can be accounted for in this condition of form; and, by assuming other conditions I cannot reconcile or account for the facts I have enumerated. For instance, if I suppose that our island was submerged in the bottom of an ocean during the transportation of the gravel, in such submergence, and the agitation accompanying it, all the materials of the drift would have been mixed up together, and the four layers of different kinds at Cunard, described at paragraph 5, would not be found so completely separated as they are, each preserving a character and composition distinct from the other. Neither, in this condition, can I conceive how the spot of limestone gravel, on the south brow of Montpelier Hill, could have been deposited there in a detached position; nor how the spot at Edmondstown, described at paragraph 13, could be left bare, without drift in the bottom of an agitated ocean, where limestone gravel all round exists on granite rock, at the same level, and some even higher. I, therefore, assume the land to have the same general form now it had at the drift period, because I cannot conceive any other condition of it in which the facts I have noted can be accounted for.

Escars.—There is no condition of the drift a greater puzzle than the formation of escars—those narrow, steep, long, crooked ridges of gravel, which abound in some parts of the country. There are none of those south of the Dodder, in the district I have been describing. I shall select the remarkable one at Maryborough, which passes by the railroad station, as one worthy of an attempt at explaining how it was formed. This gravel ridge is about four

miles in length. It begins one mile S. E. of Maryborough, and passes by the town, thence takes a N. W. direction for four miles more, and ends near Mountmellick. From Maryborough, the road leading to Mountmellick is made on the top of it for three or four miles.

Between the Slievebloom Mountains on the west, and the Stradbally Hills on the east, there is a wide valley. When this valley was submerged, a great ice floe, brought, perhaps, from Lough Derg or Lough Ree, on the Shannon, may have floated into it, then in the condition of an estuary or bay, and remained there for some time. On the receding of the water, it grounded on the slopes towards Dunamace.

Let the figure CDEF, Fig. 8, represent such a floe in plan. The east side, CD, gets fixed on high ground: when the water recedes,

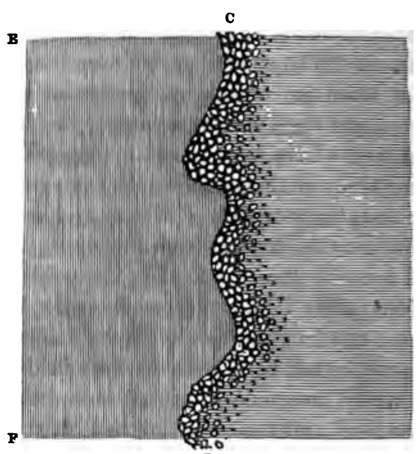


Fig. 8.

this side is supported on land, while the margin at EF subsides to a lower level, till it also rests on the ground, along the bottom of the valley. There it lies in a sloping position, its whole surface forming an inclined plane. The next wave brings another ice floe, loaded with gravel, which gets stranded or fixed over the first one, (see Fig. 9), begins to melt and deposit its contents on the surface of the lower floe. The gravel so spread on that surface, and a little agitated, slides down the plane to the lowest side, and then falls

over the edge of the inferior floe, accumulates, and forms a ridge along its margin, composed of gravel well washed, accommodating

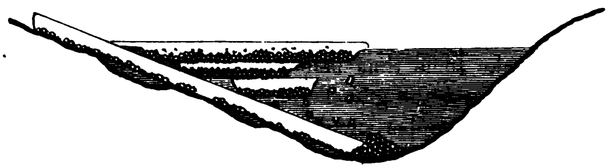


Fig. 9.

its form to all the turns in the jagged edge of the floe. After the ice melts, this ridge would be narrow, steep at the sides, crooked or straight, according to the form of the lower edge, EF, of the floe, where it was deposited, and its height would be about the thickness of the inferior floe.

An escar might be formed in this valley in another way, that is, by the iceberg stretching across the whole valley, and on the receding of the water, being supported on the slopes at both sides, would, by its own weight, break in the middle, along the line of the lowest ground, or near it, and thus form two inclined planes, meeting in the valley. See Fig. 10. In this condition, another wave came with

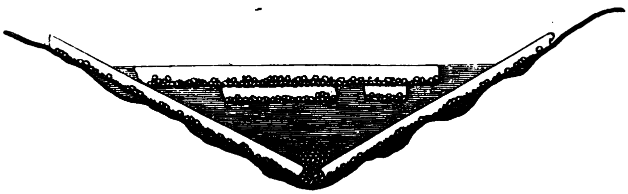


Fig. 10.

loaded floes, which got fixed over the inferior one, melted, and deposited its contents, which, sliding down the two inclined planes, met in the middle, and afterwards formed the escar.

The first large floe left in the valley would not be floated on the arrival of the second wave or tide, unless that second wave filled the valley to the depth of the first. While a sixth or seventh of its bulk, on the high margin, remained over the water of the next wave, it would not float, but keep its position and inclination until it melted. To deposit the gravel in this way, I must suppose the several successive waves were lessening in magnitude.

A floe might be loaded with gravel on the upper surface, as well as below. The case of the load on the upper surface would occur by

the sweeping of a current over the land, carrying all the gravel that a current could remove to a lower place. The surface of a frozen lake would be the natural receptacle. This might happen at the first rush of the great wave, and before the floe could be floated, as it would take some time before it would be loose enough at bottom to float, and the gravel would settle at the bottom of the current, and on the upper surface of the ice, and in this condition be floated, and carried away.

The most favourable locality for the formation of an escar on this principle would be in the vicinity of high ground, where a floe would get grounded on the top or slope of a hill, so that on the return of the wave its upper surface would form an inclined plane. It is in such positions we usually find them in Ireland.

In the vicinity of the Rathfarnham district there is a pretty large escar, stretching from the Dodder, beyond Templeogue, by Tymon, to the Green Hills. If this were formed by a floe and an inclined plane, the place for grounding the floe would probably have been Belgard Hill, to the west, which is 432 feet high, and about 140 feet higher than the general summit of the escar. The height of the ridge here is about 50 feet over the adjacent land, which I suppose to have been the thickness of the floe by which it was formed. See Fig. 11.

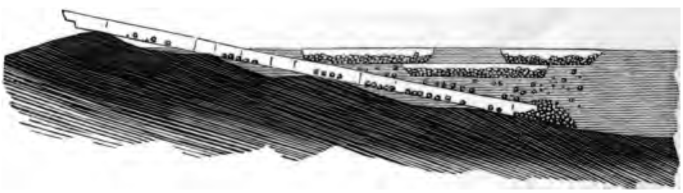


Fig. 11.

It may not be out of place here to advert to an escar in the county of Wicklow. It occurs in the valley of Kilmacanoge, two miles from Bray, on the Wexford road. This valley is covered in its lower parts with limestone gravel, from 10 to 30 feet in thickness. Pits are made in it to get manure for agricultural purposes. There is an escar on the west side of it, situated along the base of the great Sugarloaf Mountain. It has been asserted that the escars are moraines, that is, ridges of *debris*, of which the materials rolled from a hill-side above to its base below, over the sloping surface of an intervening glacier, the fragments being of the rock of the high

ground. The escar in this place is not such a moraine. The Great Sugarloaf, and every loose stone resting on its eastern slope, is quartz rock. The escar at the foot of that slope is all formed of *debris* of the carboniferous rocks, that is, chiefly limestone pebbles and sand, with fragments of black slate clay. It appears to have been formed by the grounding of an ice floe on the eastern slope of the Great Sugarloaf, the surface of which, on the receding of the water, formed an inclined plane; and other floes, loaded with gravel, having been brought over it in succeeding waves or floods, on melting, deposited their contents, which, sliding to the lower margin, formed the escar there. It is remarkable that there is no gravel higher up here, on the east face of the mountain, or west side of the valley, which may have been caused by the inclined floe intervening to prevent any deposit reaching the bottom of the water under it, at the time of the deposit.

The drift of this valley, as was said before, is limestone gravel, and it appears to lie on quartz rock, as that rock is found adjoining its edge on the east, south, and west sides, and therefore, most probly, under the drift itself. In this valley, as in other valleys of the district, the gravel is deposited on a higher level on the east side than on the west. In this case the difference is above 200 feet.

Stratification, or layers, in the gravel.—I mentioned, at paragraph 5, that, in the valley of the Dodder, at Cunard, there is a bank of drift, in which several layers appear quite distinct from one another; also, at paragraph 7, that layers are to be seen in the large gravel pit at Glassamucky, though not so well defined as those at Cunard; and at paragraph 17, mention is made, and a drawing given, of layers in the gravel near Calbeck Castle.

Layers in the drift are probably derived from several floes in succession having been brought over a certain spot, and there becoming fixed, melted, and left on the spot the drift they carried. This idea accords with the arrangement we find in the gravelly deposits, where good sections are found; for there is sometimes a layer of fine sand, of uniform appearance, covered over with a layer of coarse, round pebbles, mixed with sand. Thus layers of different kinds of drift, or different degrees of fineness, occur in one deposit, or in one escar. Each of those layers appears to have been brought from one place, and in one floe, and deposited by one effort.

The drift bank at Cunard, described at paragraph 5, I take to be a decided proof that ice was an agent in the transport of that

bank. The lowest layer of limestone gravel, the second layer of blue clay, the third brown sand, and the fourth common loose freestone, or sand of granite—four layers of four substances totally different. It is quite impossible that those four layers could have been transported in water, in a fluid state, without mixing the different materials; and they are not mixed in the smallest degree, but each layer separate and distinct in composition and appearance.

As a general rule, those layers seem to be very limited in extent, being in length from 20 to 100 yards. A good example of this is seen in cutting through an escar near Sallins, on the Great Southern and Western Railway, and another, in cutting through another escar, near Skerries, on the Dublin and Drogheda line.

It was formerly thought that, in the drift, the boulders diminished in size, as they were found moved further away from the parent rock: this is not the case. The largest boulders are often found far away from the original rock; and even in a single layer, the coarsest of the materials are frequently found uppermost, and the finer at the bottom. This is exactly the order they would assume in the original deposit in the bottom of a lough, that is, the large stones at top, and the smaller ones, with the sand going between them, to the bottom, in agitated water. The gravel, in this condition, being frozen into the water, and the whole mass floated, carried away, and fixed in a resting-place, in beginning to melt the under surface would loosen first, and the sand in the bottom would be deposited on the underlying substance: after this would come down the largest stones, which were higher up in the mass; and the whole would assume in the new deposit nearly the same order they had in the old. In this way, an ice floe would carry pebbles large or small, rounded or angular, away together, as they happened to lie in the bottom of the water before it was frozen.

I noticed, at paragraph 17, that contortions in the gravelly layers are seen at Calbeck Castle, on the south side of Kilmashogue Mountain, 1300 feet high. Those contortions I suppose to have been occasioned by several successive floes having deposited their contents over this spot, and subsequently a floe rested on the deposit; and on the subsidence of the wave that brought it, its weight pressed upon, and moved the underlying deposit in such a way, as to crumple the layers, and alter their forms to what appears in the sketch.

Layers occur in another form not yet noticed, and this form is a common one. It mostly happens where the materials are of nearly the same degree of fineness. See Fig. 12, which is a drawing of those layers, in clean sand, at the road side, south of Howth.

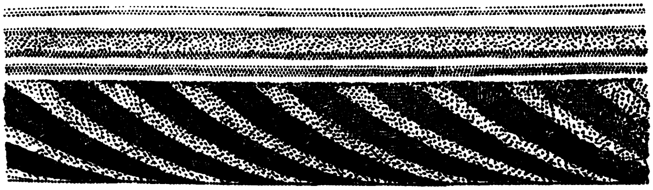


Fig. 12.

In this case, I suppose a floe in the act of depositing its sand, a current of water flowing under it, and carrying the sand some short distance, where it was deposited in this form, Fig. 13.

Fig. 13.

After it was so deposited, a floe came over it, rubbed over its surface, and carried away half its thickness, and left the layers as seen in the lower part of Fig. 12; afterwards other layers were deposited again over this mass, and took the horizontal form, as seen in the upper part of the sketch, Fig. 12.

I mentioned at paragraph 5, that a layer, 15 feet thick, of fine brown sand, and sandy clay alternating in thin laminæ, occurs in the deposit at Cunard, in the valley of the Dodder, at the upper end of Glenismaule. A layer of similar character is noticed in paragraph 17 as occurring at Calbeck Castle, between two layers of limestone gravel. Such layers of brown sand are not uncommon in deposits of drift, interposed between layers of other materials. To have such a layer of fine brown sand, without a pebble or a particle of limestone, lying between two layers of limestone gravel, appears to me a further proof that water alone was not the agent by which the drift was transported; for in this case, if it were, the

layer of brown sand could not have been kept so pure and unmixed as it is.

At Garrycastle, two miles to the east of Athlone, in the cutting of the Great Western Railway, a section is exposed, where layers of fine, brown, clean sand, from one-eighth of an inch in thickness to half an inch, may be traced for many yards interlaminated with layers of brown sandy clay of similar thickness, the latter standing out distinctly in relief in the section. Those layers are very persistent and regular over considerable areas, as if they had been deposited on the bottom of a large bay or estuary in a calm. This cutting shows the deposit here about 20 or 25 feet in thickness, but there is good reason to believe that it is much more. The height of the surface water of the Shannon below Athlone is 118 feet above sea level; the summit of the ridge at Garrycastle is 218 feet, that is, 100 feet higher; and, as no rock appears at the surface, and sand-pits are numerous along the gravel ridge which lies between those places, it is probable that the drift forms the whole of this in thickness or more.

I herewith give a sketch of the layers in a sand-pit at Loughanaskin, one mile to the east of Athlone, on the south side of the gravel ridge just mentioned (Fig. 14).

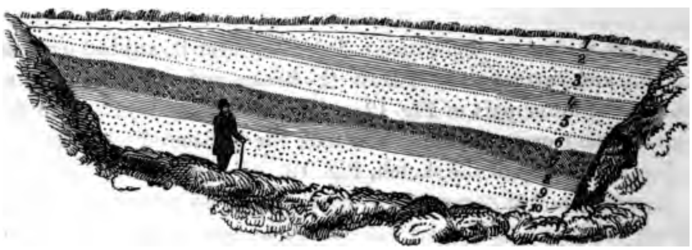


Fig. 14.

1. Vegetable mould.
2. Sandy clay.
3. Loose fine brown sand.
4. Sandy brown clay in layers.
5. Brown sand.
6. Brown sandy clay.
7. Limestone gravel.
8. Brown clayey sand.
9. Loose brown sand.
10. Brown clayey sand.

The beds of sand at Garrycastle are sometimes five or ten feet in thickness. The hill of Garrankesh and Blyry, adjoining town-

lands, show beds of pure sand, many feet in thickness, without any mixture. This drift appears to extend for some miles north and south of this locality.

I mentioned at the beginning of this paper, that in the Rathfarnham district the drift is generally limestone gravel, with an odd layer of brown sand interposed. In the Garrycastle district the case is reversed, for brown sand and brown sandy clay are the prevailing materials, and limestone gravel the exception. In the section of the cutting at this place there is a remarkable layer of limestone gravel interposed between the layers of brown sand. It is at the east end from 10 to 20 feet in thickness, but it grows thinner, as shown at Fig. 15, as it slopes downwards to the north, so as to end at 40 or 50 yards off in a wedge-shaped point, having the brown sand both above and below it.

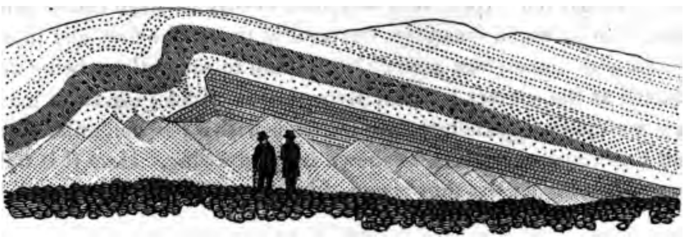


Fig. 15.

In this, and in all the diagrams which illustrate this paper, where a layer of limestone gravel lies between two layers of sand, it is represented by a tint or shade made with diagonal lines. So it is in Figs. 1, 2, 7, 14, 15, 16, 17.

I attempted to account for the origin of the great limestone gravel deposit, as having been derived from the limestone rock of the midland and western counties of Ireland; but I am quite at fault to know where the brown sand and clay came from. It is four or five square miles in extent here at least.

Of the fine sandy clay which I have noticed as standing out in thin layers in relief at Garrycastle, I dried a portion well, weighed 100 grains, and put it into a solution of acid, shaking it often. It effervesced briskly at first. After twenty-four hours I poured off the liquid when clear, and the residue dried weighed 55 grains; from this I concluded that the stiff sandy clay contains 45 per cent. of lime.

In other parts of Ireland brown sand, and sometimes yellowish sand, is a prevailing kind of drift: in the country about Swineford, in the county of Mayo, it forms the subsoil, and is several feet thick for a few square miles. It also forms the subsoil in the country between Crossmolina and Ballycastle, in the same county; but in this locality the drift is composed of two distinct layers, the upper a very fine-grained brown sand, from 5 to 10 feet thick, resting on the lower, which is a layer of limestone gravel of the native kind, or corn gravel, over limestone rock.

But to return. This layer is too long to fit with convenience in one drawing, and I have therefore separate drawings of the east and of the west ends, leaving out the middle part, which is of less interest. Fig. 16 is a drawing of the appearance of the layers of drift in the east end. The part shaded with a diagonal tint is the limestone gravel. Here it is composed mostly of large round pebbles three inches in diameter, but some of them are a foot, and those mixed with some clean sand; they adhere to each other, being cemented at the contact by a calcareous paste, which makes the mass into a strong conglomerate, and it stands with a perpendicular face, and sometimes overhangs, as shown in the drawing. Here it is well exposed, lying on the thin layers of brown sand.

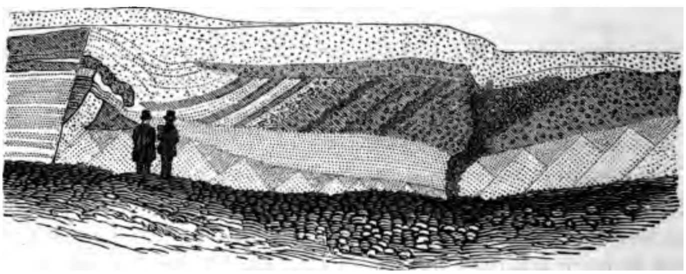


Fig. 6.

It forms the crest or summit of the great escar, which extends from Moydrum demesne to Athlone, and is continued westward beyond the Shannon into the county of Roscommon. The whole section here appears, both from the arrangement of the layers and the extent, to have been once a part of the shore of an extensive sheet of water, which lay to the northward towards Lough Ree.

The conglomeritic gravel, just mentioned as occurring at Garry-castle, and shown in the sketch (Fig. 16), formed of pebbles in contact, cemented together, is usual in large heaps of the drift. At Kilcullenbridge, in the county of Kildare, the north bank of the Liffey shows a height of thirty feet of gravel in a steep face, and in it are seen several masses of this conglomerate, projecting beyond the other gravel like large coarse flags (see Fig. 17).

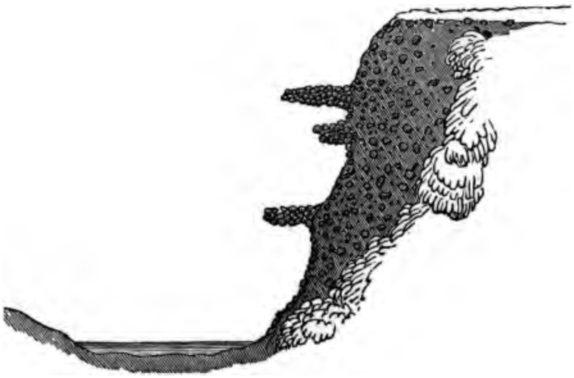


Fig. 17.

A similar appearance occurs in the townland of Tibradden, two miles south of Rathfarnham, in a high bank of gravel opposite the demense of Larch Hill. There are some projecting masses here, and many have fallen down, and are seen lying about the bottom of a large excavation, whence the loose materials were carried away for country use.

On the Curragh of Kildare, at the side of the public road, there is a mass of it containing several cubic yards. In the town of Kildare a well was sunk in the gravel, as stated at paragraph 29, and, towards the lower part, this conglomeritic gravel prevailed; the workmen were obliged to blast it, and it was said to have been more difficult to remove than solid rock.

Lakes.—Lakes in mountain districts (Fig. 18), such as those in Cumberland or in Connemara, would be a medium for the transport of boulders of large dimensions. Such lakes, often surrounded by steep precipices, would have in their beds a quantity of large blocks of stone which had tumbled from those precipices. When such a lake

became frozen, and the mass of ice by submergence floated, it would carry away those blocks on the surface of the current, perhaps for many miles, and transport them to distant places. In this way we can account for the numerous large boulders of the red granite of Connemera, which are scattered over various places in the county of Tipperary, and the transport of such blocks in general.

Fig. 18.

From the enormous amount of denudation, of which we see evidence, the valleys would have been filled up with detritus, and there would have been but few lakes left, but for the clearing out of their beds, of the stones and gravel, in this manner.

Scratches.—For producing scratches, as we find them on the slopes of hills and mountains, I suppose a lake, surrounded by precipices of quartz rock, and thousands of fragments, large and small, from those precipices, tumbled into its bottom, and forming a mass of loose materials, such as we see now on the eastern slope of the Great Sugarloaf Mountain, but larger pieces. Such a lake, frozen, floated, and borne away, thus armed on its lower surface, would be an admirable tool to scratch the side of a mountain. The rising and falling

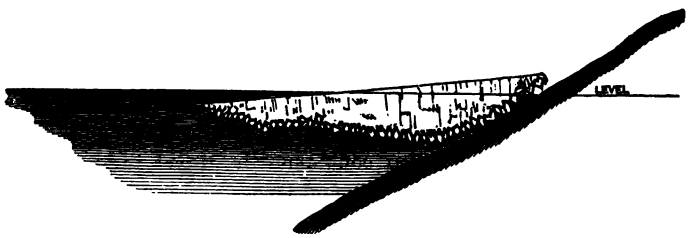


Fig. 19.

of the water in which it floated, by successive waves or tides, would give motion to such a floe, and, in contact with a mountain slope, would produce the scratches (see Fig. 19).

Bogs.—Suppose a marsh, hard frost came on, and the whole of the water was frozen into one mass, together with the gravel, sand, or mud, in its bottom. A great wave flowed over the land, the mass of ice and gravel floated away, and was carried by a current to a distant place. The displacement of the gravel would have left a hollow, and this hollow, when the waters receded, became a shallow lake; aquatic plants grew and decayed for years in succession, when a bog was formed of the remains of the vegetable matter.

Such I conceive to have been the origin of the flat bogs in our midland and western counties (see Fig. 20).

Fig. 20.

At paragraph 28 I noticed, that I had not discovered more than one place where recent marine shells are found, but I have not examined the district closely for them. Shells from the vicinity of the shores of the sea, with the gravel, sand, or mud, in which they might be embedded in the bottom of a shallow sheet of water, might be borne away to distant and higher places in the same way as described for the transport of other drift.

In paragraph 19 it is stated that no drift is found upon the northern face of the Three Rock Mountain, from its summit down to Ballally, where it is met, at from 300 to 400 feet above the level of the sea; while in the valleys which lie westward, that is, Glenismaule, Killikee, and Kilmashogue, it is found continuously from the Dodder as high as 1000, and up to 1200 and 1300 feet above sea level. The reason of the absence of gravel here I take to be, that the Three Rock Mountain, when the water was high, formed a salient promontory, and that the current going to the south-east swept by it rapidly, and left no floe aground in this space, but carried them with it towards Enniskerry, where many of them, having got into the mountain recesses of that locality, melted there, and left the thick deposits of drift visible in that neighbourhood.

The same remark, in a certain degree, may be applied to Montpelier Hill and Kilmashogue Mountain, which project northward, and separate the valleys of this district. On the northern faces of

these also, the gravel is found no higher than 500 or 600 feet, this being only about half the height to which it reaches up in the recesses of the valleys adjoining.

The highest limestone gravel I saw in the district, as stated at paragraph 17, is at Calbeck Castle, where it stands at 1300 feet above the sea. The hill of Kilmashogue is 1339 feet high. To the south-east of this summit the ridge of the hill descends gradually to a hollow of 1273 feet, or 66 feet lower; and from this hollow the surface ascends again to Fairy Castle Mountain, which is 1763 feet. When the water was 1300 feet high, it came from the north-west, up the valley between Tibradden and Kilmashogue, and flowed over this hollow or pass into the valley of Ticknock. This current brought in floes, which, perhaps, from being too large to get over the pass, grounded, and got entangled in it; melted, and left their contents on the summit of the ridge at this place. Several floes may have come this way, for the four layers of different materials shown in the drawing (Fig. 7), are due to four different floes at least. And so I consider the layers of different composition at Fig. 3, as I said before.

This circumstance, of a current having gone over a low pass on the summit of a ridge, appears worthy of notice, the gravel deposited on it being the highest in the district, and showing that the floes were not everywhere fixed at the highest limit the water attained the time this drift was deposited; for we must suppose the surface of the water in all parts of the district was 1300 feet high, as well as at Calbeck Castle, although it did not ground floes, or leave drift so high anywhere else, as far as I observed; and that therefore drift is not found in all places covered by water at that time.

It appears to me that the transported drift deposited on the higher slopes, say over 500 feet above the sea level, was brought by means of a few great waves, for it is neither constant on the surface of the land above this height, nor of great thickness, except in a few places; but that below this line a much greater quantity has been left, probably from the waves having had something of the nature of tide-waves returning periodically, and with a greater number of such returns bringing more materials for drift over the low grounds than was carried over the higher slopes. I may add, that the great thickness of drift in Dublin, Meath, Kildare, and

Carlow, are below this line, as well as most of the escars. It is highly probable that some of the drift on the low-lying lands may have been transported in the bottom of currents of water without the intervention of ice; but, in this case, I should say not to a great distance.'

I have thus laid before the Society an account of my observations of this district, and of the views I entertain regarding the causes which produced what I observed in the examination. I fear I have been rather tedious in my descriptions, but I have a great desire to be clear in narrating the facts, which, I hope, are related in a manner sufficiently simple to be understood.

May 10th, 1854.—"On the different Analyses of Killinite;" by the Rev. J. A. Galbraith, M. A., Professor of Natural and Experimental Philosophy in the University of Dublin.

Mr. Galbraith communicated to the Society the results of the analyses of two specimens of Killinite, one of which was found in the quarries of Dalkey, county Dublin; the other, about a mile and a half south of this locality, within the demesne wall of Victoria Castle. The first specimen was obtained from Dr. Aquilla Smith, in whose cabinet it lay for some years before being submitted to analysis. The second was operated on immediately after its being removed from the granite vein in which it was found by Professor Haughton.

Analysis of Specimen found in Dalkey Quarry.

	Per Cent.	Atomic Quotients.		Proportionals.
SiO_3,	50·11	1·106		3·85
Al_2O_3,	29·37	0·571		1·99
FeO,	2·23	0·062		
CaO,	0·34	0·012		
MgO,	1·03	0·051	0·287	1·00
KO,	6·71	0·143		
NaO,	0·60	0·019		
HO,	8·03	0·892		3·10
	98·42			

Analysis of Specimen found at Killiney, near Victoria Castle.

	Per Cent.	Atomic Quotients.		Proportionals.
SiO_3,	50·45	1·118		3·92
Al_2O_3,	30·18	0·585		2·06
FeO,	3·53	0·098	0·284	1·00
CaO,	0·00	0·000		
MgO,	1·09	0·054		
KO,	4·81	0·102		
NaO,	0·95	0·030		
HO,	7·58	0·842		2·96
	98·54			

These analyses show that the mineral consists of:—

SiO_3,	4	equivalents.
Al_2O_3,	2	„
RO,	1	„
Water,	3	„

And that its rational formula is,

$$(ROSiO_3 + 2\ Al_2O_3\ 3\ SiO_3) + 3\ HO.$$

The following analyses have been made by Lehunt and Blyth, *vide* Dana's " System of Mineralogy:"—

LEHUNT.

	Per Cent.	Atomic Quotients.		Proportionals.
SiO_3,	49·08	1·083		3·81
Al_2O_3,	30·60	0·595		2·09
FeO,	2·27	0·063	0·284	1·00
CaO,	0·68	0·024		
MgO,	1·08	0·054		
KO,	6·72	0·143		
HO,	10·00	1·111		3·91
	100·43			

The water in this analysis amounts to 10 per cent., a result which is confirmed by Blyth. These chemists may probably, as they worked in the same laboratory, have examined the same specimen, which, according to my experiments, would appear to have been in some exceptional condition, affected perhaps with hygroscopic moisture.

BLYTH.

	Per Cent.	Atomic Quotients.		Proportionals.
SiO_3,	47·925	1·058		3·86
Al_2O_3,	31·041	0·604		2·20
FeO,	2·328	0·064	0·274	1·00
MnO,	1·255	0·032		
CaO,	0·724	0·026		
MgO,	0·459	0·023		
KO,	6·063	0·129		
HO,	10·000	1·111		4·05
	99·795			

The near agreement of these analyses with those now presented to the Society, in all the mineral constituents, is remarkable. In the water of combination there is a striking difference. According to these chemists the formula is,

$$(KOSiO_3 + 2\ Al_2O_3\ 3\ SiO_3) + 4\ HO.$$

In consequence of this discrepancy several experiments were made on both the specimens by Mr. Galbraith, in order to determine the amount of water with the greatest accuracy,—the results of all these trials gave the same quantity.

An analysis of this remarkable mineral was communicated to the Society, in the year 1849*, by Mr. J. W. Mallet. In many respects it differed materially from those given above, the rational formula deduced by him bearing no resemblance to either of those already given. An arithmetical error may be discovered in the discussion of his analysis, which, if corrected, would lead to a result which approximates to what must now be agreed on as the true rational formula, at least so far as the mineral constituents are concerned. In Mr. Mallet's communication he mentions that he detected the presence of lithia in the specimen he examined, and in his analysis estimates its amount. Mr. Galbraith instituted an accurate search for this rare oxide in both his specimens, but was unable to detect the slightest trace in either.

In the Dalkey specimen, which was a remarkably fine one, the specific gravity was determined as follows:—

Sp. gr. of mineral in mass $= 2·678$.
Sp. gr. of mineral in fragments $= 2·688$.

* Journal of Geological Society, vol. iv. p. 142.

June 14th, 1854.—"Geological and Statistical Notes on Irish Mines;" by the Rev. Samuel Haughton, M. A., Professor of Geology in Trinity College, Dublin.

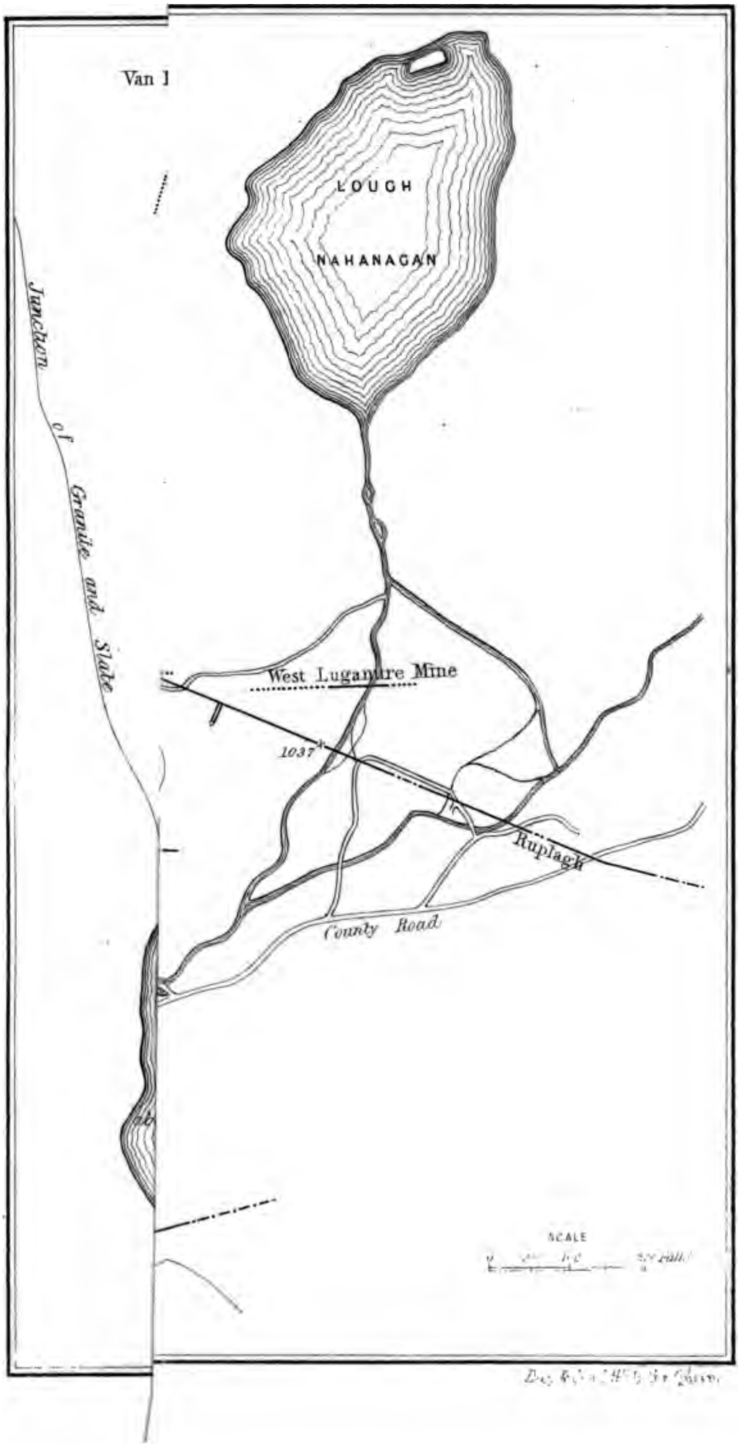
No. II.—Luganure Lead Mines.

The mines which are known by the name of the Luganure Lead Mines are the property of the Mining Company of Ireland, and derive their name from that of one of the numerous lodes formerly worked in this district. The mines occur in two valleys, Glendasane and Glendalough, the streams from which unite at a few hundred yards below the Seven Churches. A reference to the accompanying Map of the district, which I have been allowed to copy from the excellent mining Map made for the Company by the Messrs. Clemes, will show the relations of the lodes which constitute the mines better than a detailed verbal description. The best method of describing the lodes will be to follow the course of the Glendasane valley from its junction with that of Glendalough.

The general direction of the lodes in this valley is N.S., and they occur in the following order:—

1. Fox Rock Lode,	underlay	1 ft. 6 in. per fath. W.
2. Moll Doyle Lode,	,,	45° W.
3. Hero Lode,	,,	10 in 22 W.
4. Ruplagh and Hawk Rock Lode,	,,	2 ft. 7 in. per fath. W.
5. West Luganure,	,,	2 ft. 5 in. per fath. W.

It will be seen, by an inspection of the Map, that the Old Luganure lode is the prolongation of the West Luganure; and that the Luganure lode, which is that now principally worked, is the southern prolongation of the old Luganure lodes. The lodes just mentioned, with the exception of the last, are not now worked, and consequently the mine has assumed the name of the Luganure Lead Mine. The lofty ridge of mountain called Comaderry separates the valleys of Glendasane and Glendalough; and in October last the workings on the Luganure lode had reached, in a southerly direction, the vertical plane, whose intersection with the surface forms the watershed of the two valleys. The Luganure mine is worked by a series of adits driven on the lode, and the mine is unwatered and the ore extracted by means of these adits. The drawing of the ore from the mine is economically effected by mules, which


Van
LOUGH
NAHANAGAN
Junction of Granite and Slate
West Luganure Mine
1037
Ruplagh
County Road
SCALE

June 14th, 1854.—"Geological and Statistical Notes on Irish Mines;" by the Rev. SAMUEL HAUGHTON, M. A., Professor of Geology in Trinity College, Dublin.

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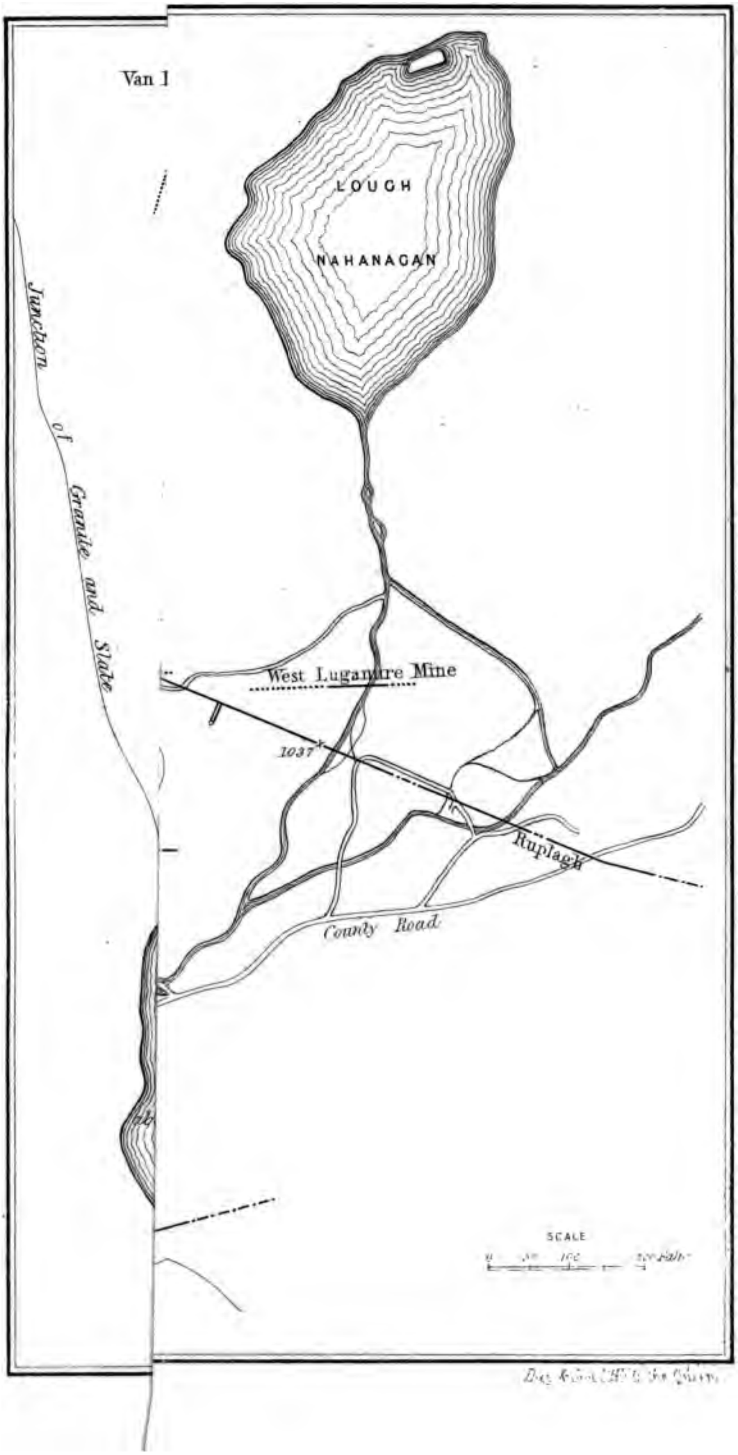
2. Moll Doyle Lode,	„	45° W.
3. Hero Lode,	„	10 in 22 W.
4. Ruplagh and Hawk Rock Lode,	„	2 ft. 7 in. per fath. W.
5. West Luganure,	„	2 ft. 5 in. per fath. W.

It will be seen, by an inspection of the Map, that the Old Luganure lode is the prolongation of the West Luganure; and that the Luganure lode, which is that now principally worked, is the southern prolongation of the old Luganure lodes. The lodes just mentioned, with the exception of the last, are not now worked, and consequently the mine has assumed the name of the Luganure Lead Mine. The lofty ridge of mountain called Comaderry separates the valleys of Glendasane and Glendalough; and in October last the workings on the Luganure lode had reached, in a southerly direction, the vertical plane, whose intersection with the surface forms the watershed of the two valleys. The Luganure mine is worked by a series of adits driven on the lode, and the mine is unwatered and the ore extracted by means of these adits. The drawing of the ore from the mine is economically effected by mules, which



Day & Son Lith's to the Queen.

can draw three waggons at each load by the aid of a small iron tramway.

The following is the series of adits in descending order, with their respective heights above the sea level, and the distances to which each has been driven southwards under Comaderry Mountain:—

	Height above Sea.	Length.
Shallow Adit, ...	1667 ft.	166 fath.
Weavers' Level, . . .	1552 „	273 „
Deep Adit, ...	1438 „	518 „
Richard's Adit, . . .	1037 „	330 „

The last-named, or Richard's Adit, is the lowest adit that could be driven on the run of the lode, as its mouth is nearly on a level with the stream from Lough Nahanagan. The economical working of the Luganure mine depends on the fact that a great part of the lode lies above the adit level; if it should become necessary to sink below the lowest adit and pump the water, it is to be feared that a large proportion of the profits of the mine would be consumed in the fuel and machinery necessary for unwatering the workings. For the purpose of forming an idea of the adits that could be driven on each lode, I measured barometrically the height of the points where each lode crosses the bed of the Glendasane river, as this point determines the lowest level at which an adit could be made on the lode. The following are the results in descending order:—

Intersection of Lodes with River Glendasane above Sea Level.

West Luganure, ...	1112 feet.
Ruplagh, ...	1040 „
Hero, ...	967 „
Moll Doyle, ...	776 „
Fox Rock, ...	514 „

The last-named lode does not come down to the level of the river, but its direction prolonged would cut the stream at the height above the sea here given. The figures just tabulated show the heights below which it is impossible to unwater each mine by simple levels. A cross course, running E. W. magnetic, intersects the bed of the river at the same point in which it is intersected by the production of the Fox Rock lode; and as this course makes an

angle of 64° with the average direction of the lodes, it was at one time proposed to drive an adit on the cross course, which would unwater all the lodes to the level of 514 feet above the sea level, and at the same time probably discover other lodes.

This cross course adit was driven 45 fathoms, and then abandoned in consequence of the cost of driving, which amounted to £12 per fathom, and the great distance which it should be driven in order to intersect the important lodes of Luganure, this distance being 870 fathoms. These circumstances render it very questionable whether this adit would have been ever completed, but the necessity for it has fortunately been completely removed by a discovery made some time since by the son of Captain Clemes, the intelligent Agent of the Mining Company at Luganure, who succeeded in finding the prolongation of the Luganure lode at the Glendalough side of Comaderry Mountain. This new lode, which has been called the Glendalough lode, has been opened upon by means of two levels; and a third, lower down, has been proposed, which has not yet been driven upon the lode.

	Height above Sea.	Length.
Upper Adit Level, ...	1105 ft.	147 fath.
Middle Adit Level, ...	847 „	95 „
Lower Adit, ...	491 „	70 „

It will be seen at once that these heights are much lower than those of the adits in the Glendasane valley, and as the surface of Glendalough Lake is only 439 feet above the sea level, it is plain that, when the communication is opened on the lode between the two valleys under Comaderry, the unwatering of all the Luganure lodes to this depth will be effected at a very small cost. The distance yet remaining to be driven on the lodes before meeting is now less than 260 fathoms.

It may be seen from the Map that the Glendalough lode is parallel in direction to the Ruplagh and Hawk Rock lodes, which intersect under a small angle the old Luganure and West Luganure lodes, the prolongation of which to the south is the part of the Luganure mine now worked with most vigour. Two opinions may be formed of the Glendalough lode: either that it is the prolongation of the Ruplagh lode, heaved to the left through about 225 fathoms, or that it is the Luganure lode which bends in passing under Comaderry. I incline myself to the former opinion, and in case it should

prove correct, a second junction of lodes should be expected at about 250 fathoms from the mouth of the upper Glendalough adit.

High up the Glendalough valley, the mine known by the name of Van Diemen's Land occurs: it has been opened in two small adits.

	Height above Sea.	Length.
The Deep Adit, ...	1179 ft.	13 fath.
Cross Course Adit, ...	1256 „	18 „

This mine is interesting from the fact of copper pyrites having been found in it, and from the circumstance that it is on a cross course, bearing E. W. (Mag.), which extends eastwards beyond the Glendalough mine, passing the mouth of the upper adit level, and throwing off a southern branch, which is known by the name of Weaver's Old Level, from the fact of Mr. Weaver's having driven on it for a short distance, 69 fathoms.

The following Table, for which I am indebted to Mr. Purdy Allen, the Secretary of the Mining Company of Ireland, shows the produce of the mines for the last twenty years:—

Produce of Luganure Mines, County of Wicklow.

Year.	Produce.	Value.		
	Tons.	£	s.	d.
1834	352	4362	16	1
1835	536	5840	6	5
1836	820	11506	10	8
1837	1107	11060	8	11
1838	1045	10964	17	4
1839	760	7531	7	7
1840	754	7641	16	5
1841	608	6849	18	7
1842	732	7462	10	4
1843	517	4796	8	4
1844	418	3401	5	5
1845	448	4717	15	5
1846	440	4670	15	4
1847	445	4470	14	8
1848	393	3833	5	3
1849	471	4203	11	2
1850	592	5434	3	5
1851	715	8138	14	9
1852	996	10127	11	9
1853	932	11742	11	8

Mineralogical Observations on the Luganure District.—It is a common opinion among miners, who derive their experience from Cornwall only, that lead is not found in granite. The Luganure mines form a remarkable proof of the danger of such generalizations from one mining locality, as it may be seen by a glance at the Map that the mines are worked exclusively in the granite.

The lodes are formed principally of a fine-grained granite, differing in texture from the granite of the country, and generally decomposed. An excellent general description of the character of the lodes of this district has been given by Mr. Warrington Smyth in the "Records of the School of Mines," vol. i. part 3, to which I shall refer for a description of the lodes more elaborate than is suited to this communication, which only professes to be taken from notes recorded during some visits to the Glendasane valley.

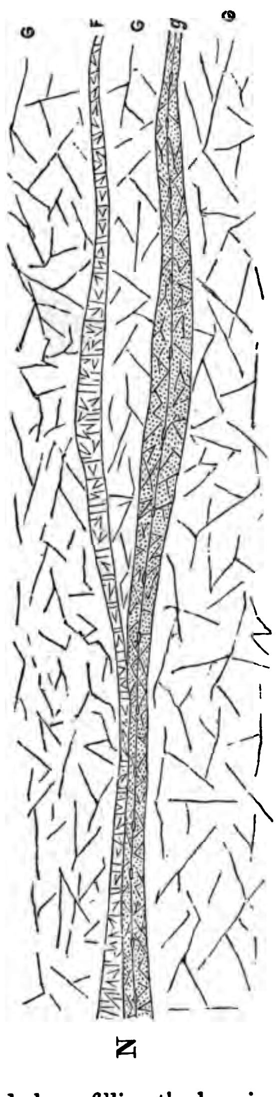
Mr. Smyth's figures (pp. 355, 356) will convey, to one who has not visited the interior of the mine, a correct idea of the appearance of the lode, which is generally composed of two parts: one half next the hanging wall being a decomposed elvan, or fine-grained granite; and the other half, next the foot wall, being composed generally of quartz, and carrying in it the greater part of the lead ore. Such, at least, is the character of the lode in the Glendasane valley; but the same lode in Glendalough valley contains large quantities of fluor spar, replacing the quartz of Glendasane, and the lead ore is not confined to the fluor, but sometimes, although rarely, appears in veins in the very centre of the decomposed granite, which constitutes the hanging side of the lode.

The lode varies in width from 6 inches to 3 and 4 feet, and wherever it is wide enough to observe the different parts of which it is composed, it presents the appearance of being formed of two distinct parts, as has been just described, each occupying about half the breadth of the entire lode.

The occurrence of fluor spar in the southern part of the lode at Glendalough is interesting, as it connects this mining district mineralogically with the mining district of Glenmalure in the next valley, south of Glendalough. It was formerly considered that the occurrence of fluor spar in Glenmalure distinguished it from the Luganure district.

The fluor spar at Glendalough is mostly massive, of a pale violet green colour, reminding one of the fluor spar of East Wheal

Crofty and the neighbouring mines in the Redruth district, but it sometimes occurs crystallized, of a light brown colour, and in cubes two inches in dimensions.

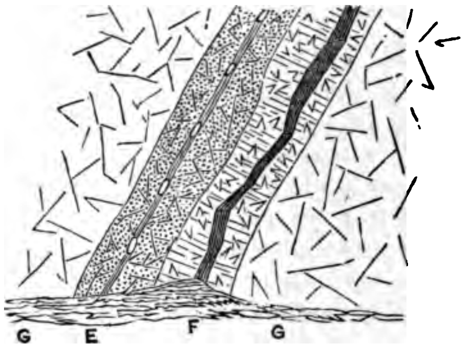


The remarkable division, just adverted to, of the lode into two physical planes, containing different minerals, is well shown by the accompanying plan, showing the manner in which the elvan lode is separated from the quartz and fluor spar lode by a "*horse*," or lenticular mass of granite similar to that of the country. This plan was drawn at the north end of the middle adit of Glendalough, and is made to scale, the total length figured being five fathoms.

In this plan GGG is the granite of the district, and the central portion, or "horse," is not distinguishable in texture from the surrounding granite. F denotes the part of the lode which is composed of fluor spar and crystallized quartz; and *g* denotes the other half of the lode composed of a fine-grained decomposing granite, or elvan, carrying with it distinct veins of lead ore in the central portion.

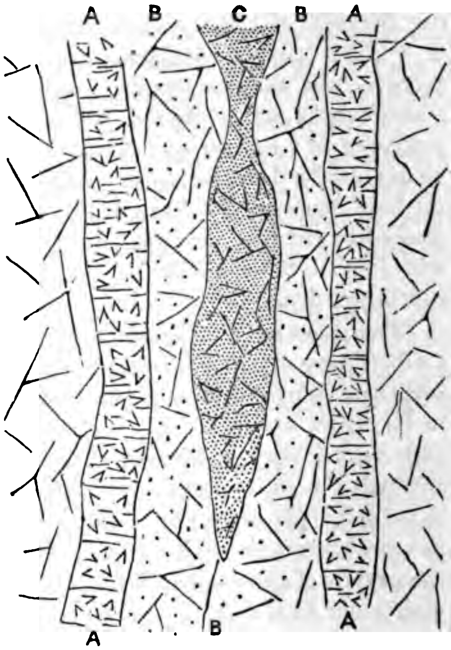
The quartz and fluor spar lode carries a rib of lead ore about 6 inches wide, and the decomposed elvan lode contains in its centre a vein of lead ore from 1 inch to 2 inches, which was constant through the entire length of the plan. A section of the north end is shown in the next figure, in which GG denotes the granite of the country, F the lode of quartz and fluor spar, with a wide vein of lead in its centre, and E the decomposed elvan, filling the hanging side of the lode, and containing occasional veins of lead ore.

The "horse" just described in Glendalough mine presents a striking instance, on a large scale, of what may be seen in miniature



in the veins of granite intersecting other granite all through this part of Wicklow.

I subjoin one of many instances from my note-book, representing in miniature the mode of formation of the Luganure lodes.



In this sketch, AA and AA, the sides of the granite vein, are composed of large crystals of quartz and mica, without any felspar; the main body of the vein, BBB, is composed of quartz, felspar, and mica, of the average size, and well defined; and C, the portion analogous to the "horse" of the lode, is an elvan of felspar and mica, very fine grained, and without any perceptible admixture of quartz:

the total width of the vein is 7 inches. In this, as in many other cases, we perceive a tendency in the quartz to segregate itself from the main body of the vein, the greater part of the quartz being deposited on the sides of the vein, and none in the centre. Such I conceive to have taken place on a large scale in the Glendasane and Glendalough lodes. The decomposed elvan of the hanging wall of the lode is composed principally of decomposing felspar, and a pale-green or rose-coloured "steatitic" mineral, which has been often mistaken for true soapstone, an analysis of which, showing its true character, I subjoin, p. 176.

This portion of the lode contains but little quartz, this latter mineral appearing to be collected altogether in the half of the lode adjoining the foot wall; and associated with the quartz is found fluor spar, calc spar, and the principal deposit of galena in the lode. This portion of the lode is more pervious to water than the upper portion, and it is impossible to say how much of its contents may have been introduced by aqueous action, after the lode itself was formed by the liquid molten dyke of granite. The lead ore appears, from the facts described (pp. 173, 174), to have been introduced after the entire lode was formed; and in this respect it conforms to a rule, of which I have seen examples both in this country and Cornwall, viz., that *the metalliferous deposits in lodes are frequently the last formed deposits.* I shall not now enter upon this wide and important subject, to which on some future occasion I may revert, but shall conclude these notes by giving an accurate mineralogical description of a few of the principal minerals occurring in abundance in this district.

1. *Pale-green Steatitic Mineral in the Lode.*—I have already mentioned this mineral as occurring in the lodes and neighbouring granite, and as having been often taken for true soapstone.

A chemical examination of it shows it to be a mineral arising from the imperfect decomposition of felspar and mica, consisting partly of an hydrated silicate of alumina, and retaining much of the original alkalies of the minerals from which it is formed. It contains such a small quantity of magnesia (only 1½ per cent.), that it cannot be considered as even approximating to the character of a steatite, with which it has only the property in common of feeling unctuous to the touch.

The following is its composition in 100 parts:—

Loss by ignition,	4·79
Silica,	50·00
Alumina,	33·93
Lime,	Trace.
Magnesia,	1·53
Potash,	7·17
Soda,	0·90
	98·32

A similar pale green steatitic mineral, found in decomposing granite near Dundrum, in the cuttings of the Dublin and Bray railway, has been examined by Mr. England in the Laboratory of Trinity College, with the following result:—

	Green Steatitic Mineral.	Potash Felspar.
Loss by ignition,	3·00	0·00
Silica,	66·12	64·80
Alumina,	19·67	18·38
Lime,	1·12	0·00
Potash and Soda,	10·09 (by diff.)	16·82
	100·00	100·00

I have placed beside the latter analysis the theoretical per-centages of potash felspar, a comparison of which, with the two analyses, shows that the steatitic mineral under discussion is in the main a decomposed felspar, produced by the washing out of a certain quantity of the silicate of potash. The green colour is probably due to the presence of iron, the quantity of which, however, it was not thought worth while to determine.

2. *Felspar of the Granite of Glendalough.*—A chemical examination of the felspar of Glendalough, the particulars of which I here give, shows it to be the ordinary potash felspar of the Dublin and Wicklow granites.

Sp. gravity = 2·453

Loss by ignition,	0·60
Silica,	63·60
Alumina,	18·84
Peroxide of Iron,	Trace.
Magnesia,	0·40
Lime,	Trace.
Potash,	14·33
Soda,	1·92
	99·69

3. *Mica of the Granite of Glendalough.*—The mica occurring in

the granite of this part of Wicklow presents itself in two distinct conditions: one, a transparent gray mica, with a high reflecting power; and the other, a dark, brownish-black mica, possessing apparently considerable absorbing power for light. This difference I am inclined to consider altogether optical. I was unfortunately not able to procure a sufficient quantity of the black mica from Glendalough for analysis; but I endeavoured to supply this defect by analyzing a mica containing numerous specks of black mica, intimately mixed with a more transparent variety, and which is abundant in the granite of the Three Rock Mountain, county of Dublin.

The chemical examination of the gray mica from Glendalough, and the gray speckled mica from the county of Dublin, shows that they must both be considered as belonging to the species known as Margarodite to mineralogists, with empirical formula,

$$3\ SiO_3 : 2\ R_2O_3 : RO,$$

together with fluorine and water.

While the chemical characters of these micas is thus similar, the optical properties are very different, as proved by the different angles between the optic axes, which I have carefully ascertained.

Gray Mica from Glendalough.

Sp. gr. = 2·793. Angle between Optic Axes = 70°4′.

	Per Centage.	Atoms.		Integer Atoms.
Loss by ignition,	6·22	0·691	0·691	2
Silica,	44·71	0·987	0·987	3
Alumina,	31·18	0·606	0·664	2
Peroxide of iron,	4·69	0·058		
Lime,	1·09	0·035	0·332	1
Magnesia,	0·90	0·045		
Potash,	9·91	0·211		
Soda,	1·27	0·041		
	99·92			

The quantity of fluorine in this mica was not determined, but it can only be considered as forming a very small part of the loss by ignition, as compared with the water; the numbers in the atomic columns are computed on the supposition that the greatest part of the loss is water; from which we may deduce the probable formula of this hydrated mica as,

$$RO,\ SiO_3 + 2\ (Q_2O_3,\ SiO_3) + 2\ HO;$$

R denoting calcium, magnesium, potassium, sodium; and Q, iron and aluminum.

Speckled Mica from Three Rock Mountain.

Angle between Optic Axes = 58°·8′.

	Per Centage.	Atoms.		Integer Atoms.
Loss by ignition,	5·43	0·603	0·603	2
Silica,	43·47	0·959	0·959	3
Alumina,	31·42	0·611	0·670	2
Peroxide of iron,	4·79	0·059		
Lime,	1·38	0·049	0·379	1
Magnesia,	1·13	0·056		
Potash,	10·71	0·228		
Soda,	1·44	0·046		
	99·77			

The proportion of the protoxides to the peroxides and silica in this analysis is not so perfectly in accordance with Margarodite as in the former analysis, but it agrees better with this mineral than with any other variety of mica with which I am acquainted, and I believe it to be a true Margarodite.

The difference in appearance of the two micas I suppose to be due to their different molecular conditions as to light, which view is confirmed by the remarkable difference in the angle between the optic axes in the two minerals.

Judging from a passage in Mr. W. Smyth's Report, p. 352, he appears inclined to attribute the difference of colour and appearance to the presence of soda in the black mica, called by him Soda mica, a view which does not appear confirmed by the analyses I have made.

June 14th, 1854.—" On an Outlier of Carboniferous Limestone, at Taghmon, in the County of Wexford;" by the President.

The subject of denudation is one of great interest to the geologist, though it is a branch of the science but little worked. The only considerable paper directly treating of it, that I know of, is one by my friend and colleague, Professor Ramsay, entitled, " On the Denudation of South Wales and the adjacent counties of England," and published in the first volume of the Memoirs of the Geological Survey.

It is not very often that we meet with so neat an example prov-

ing a vast amount of denudation as the one I am going to describe to you, and though the facts have no great novelty, I may therefore be excused for laying them before you.

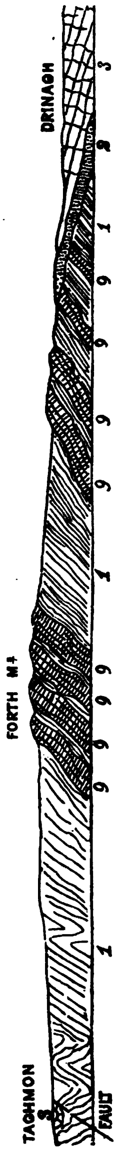
The neighbourhood of Wexford is, as most of you are well aware, composed of some low hills of green and purple grit and slate, with great masses of quartz rock striking from the town in a W. S. W. direction to the rough eminences and crags that make what is called Forth Mountain, so conspicuous a feature in the country. These rocks belong to the Cambrian formation of the Geological Survey. Both to the north and to the south of the town, thin skirts and strips of old red sandstone rest upon the edges of these rocks, dipping gently to the eastward, in which direction they become covered by beds of carboniferous limestone. In one place, just south of the town, at a place called Kerloge, the carboniferous limestone seems to overlap the old red sandstone and rest directly on the Cambrian rocks; or, at all events, in the eight or ten yards that intervene between the two no old red sandstone is visible.

The old red sandstone is a coarse red sandstone often passing into a conglomerate, containing pebbles of white quartz, evidently derived from the quartz rocks of the Cambrian formation, which are full of quartz veins. At one spot, at Kerloge, even the lowest bed of the limestone itself contains small pebbles of quartz, as may be seen in a small quarry, about twenty yards from a cliff of quartz rock. The old red sandstone is evidently nothing more than an old Devonian beach, and we have, in these pebbles in the limestone, clear proof of the existence of sea and shore here for a short time, even in the carboniferous period.

One thing, at all events, is very clear from the examination of this and the adjacent country, that movements of elevation sufficient to set completely on edge the old Cambrian and Lower Silurian rocks, and forces of denudation sufficient to remove all, or nearly all, that portion of the upraised masses that were above the existing outline of the land, took place *previously* to the deposition of these Devonian and carboniferous rocks. The general outline and contour of the ground, whether above or under water, must have been, before the deposition of the old red sandstone, very much what it now is; any subsequent denudation having been confined to eroding the present hollows and valleys in the Cambrian and Silurian rocks, and, perhaps, taking off a comparatively thin shell from their higher ground.

Is this all that can be said, however?—or has there not been a great deposition of materials over all this country since the period of the old red sandstone, and a corresponding subsequent denudation of nearly the whole of these materials.

That this is true to some extent is at once obvious, for we have no reason, but rather the contrary, to suppose that the Old Red Sandstone, and more particularly the Carboniferous limestone, were originally confined within their present boundary. The beds of the Carboniferous limestone rise up one after another at an angle often of 20°, from the district of Drinagh towards the high land of the Forth Mountain. How far did these beds extend when they were horizontal? Now, this question we should have no means of answering if it were not for a little patch of Carboniferous limestone which occurs near Taghmon, five or six miles from the general boundary of this formation. This little patch is about 150 yards long by 50 broad. It consists of beds of dark limestone, with thin, black, earthy shales interstratified exactly like the beds at Kerloge and Drinagh. It contains abundance of corals of the genera Syringopora, or Tubulipora, and many smaller corals, with crinoidal stems and spirifers, like those so frequently seen in the lower limestone of Hook Point and elsewhere. The beds in the quarry are much bent and contorted, being squeezed into a fold of the Cambrian rocks, which consist chiefly of quartz rock on the western side, and green and purple slate, with quartz rock, on the east. On the west side the beds of limestone may have once reposed on the quartz rock, but on the east the limestone abuts against the Cambrian rocks. That boundary is, therefore, clearly a fault, and it is not impossible that the western boundary may be so too, and the limestone be now lying like a compressed and broken wedge in the hollow of a pair of trough faults. In that case its original position may have been a good deal higher than its present one with respect to the rocks by which it is surrounded, but it is not likely that that was the case



to any vast extent. It has been preserved from denudation by the way in which it has been packed into that part of the Cambrian rocks which has just been spared by that action.

Its existence here, however, makes it in the highest degree probable, that the whole country was once covered by Carboniferous limestone; since, if we bring it thus far, there is no reason why we should not suppose it to have extended up to the flanks of the granite mountains of Mount Leinster and Black Stairs. Neither do I see any good reason why we should not believe the whole of the Carboniferous formation, up to the very top of the coal-measures, to have spread over this tract, and thus the granite mountains themselves to have been buried deep under the level plain of a great coal-measure tract, that once spread over the most, if not the whole, of Ireland.

The occurrence of this little quarry may seem a very slight peg to hang so large a hypothesis upon; nevertheless, it is an idea that has often been thrust, as it were, upon my mind from reasonings and considerations derived from various sources. Neither should I be inclined to confine this hypothesis to Ireland. The well-known occurrence of a similarly circumstanced, but much larger, patch of Carboniferous limestone, at Hafod y Calch, near Corwen, in North Wales, let into the country and preserved on the downthrow side of the great Yale and Bala fault, eight or ten miles from the nearest part of the general boundary of the formation, gives us exactly a similar result for Wales, and makes it probable that a large part, if not the whole, of Denbighshire and Merionethshire, if not also of Caernarvonshire, may have been once covered with the Carboniferous limestone, and if with that, why not with the Millstone grit and Coal-measures? Wherever the dislocations have been sufficiently powerful to let them into the present contours of the country, there one or other of the Carboniferous rocks forms the surface of the ground: the inference is then, if that surface had been sufficiently high,—in other words, if denudation had not taken place to the extent it has,—they would have formed the surface of the whole or major part of the country.

June 14th, 1854.—"Note on Mr. TRIPHOOK's Paper 'On the Geology of the Neighbourhood of Skull;'" by W. L. WILLSON, Esq., of the Geological Survey of Ireland.

IN the last Number of the Journal of the Geological Society of Dublin there is a paper by Thomas D. Triphook, Esq., "On the Geology of the neighbourhood of Skull, accompanied with a Geological Section from Long Island to Mount Gabriel." I regret that, in justice to myself and the service to which I belong, I feel bound to make a few remarks upon this paper. During the summer of 1853 I was stationed at Skull, where I made the acquaintance of Mr. Triphook, to whom I gave every information in my power regarding the object and working of the Geological Survey, freely exhibiting and explaining my maps to him, and describing the results at which I had arrived. Having been particularly requested by Mr. Triphook to show him our mode of constructing geological sections, I drew out one (from my partially worked maps) running from Long Island to Mount Gabriel, which section I lent him for an example. I was, therefore, not a little surprised to find, on receiving the Geological Journal containing Mr. Triphook's paper, that the section which accompanied it was neither more nor less than a reduced copy of the one I had lent him, and which I have by me at the present time. The principal geological facts also mentioned in his paper are those with which I furnished him. Had there been the slightest acknowledgment of the source from which these facts were derived, I should not have felt called upon to lay this statement before you; but I am the more induced to do so because subsequent examination showed me that there is probably an error in the thickness of the lower rock, called "purple slate," to the amount of about 1500 feet: a concealed but highly probable anticlinal, where the beds are all nearly vertical, reducing the actual thickness of the "purple slate" appearing in the line of section by about that amount.

P. S.—Since writing the above I have communicated with Mr. Triphook, who informs me, that the paper and section in question were originally sent in as an exercise for his examination in Trinity College, Dublin, and that when Professor Haughton proposed to him to lay them before the Society, he, from want of thought, neglected to add any mention of the authority from which they were derived,—an inadvertence which he deeply regrets.

June 14th, 1854.—"Account of a Reconnaissance of the Nurbudda Valley in Central India;" by ARTHUR A. JACOB, ESQ., Engineer to the Bombay, Baroda, and Central India Railway Company.

THE increasing commercial importance of the East Indies, and the interest evinced by all classes in their welfare, must be my apology for placing before the Society the following sketch of a tour made by me during the past cold season along the valley of the river Nurbudda. My object in examining it was to enable me to report upon the feasibility of establishing an iron manufacture in connexion with the Bombay, Baroda, and Central India Railway. This Company, which projects a great length of line along the western coast and through the upper provinces of India, contemplate the manufacture of their own rails from the vast iron deposits of Malwa—a scheme which the richness of the ore, and the cheapness of fuel, render most practicable.

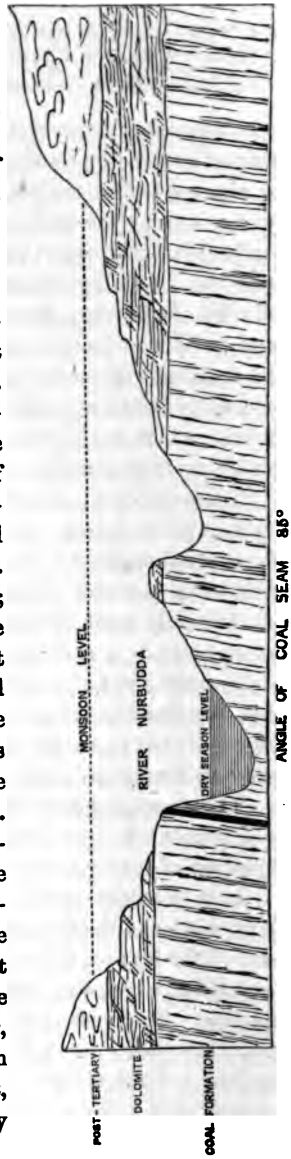
I came upon the river Nurbudda at Burwayee, near the point where the sandstone appears from beneath superimposed basalt. Here commences the great iron district. The ore found is the anhydrous peroxide of iron, occurring in the basalt in veins; it was formerly much used by the natives, but the country being now pretty clear, they cannot compete with those workers who have timber at hand; but about fifteen miles north of Burwayee, at Kandcoot, is a fine mine of ochreous brown hematite, on the Holkar territory—it has formerly been largely worked; the ore yields by dry assay an average of 37·22 per cent.

The most primitive form of Catalan forge is used by the few poor people who now earn a livelihood in the manufacture. A description of it may not be amiss.

It is in height from 3 to 4 feet; the top section 20 inches by 10 inches; and the bottom section 23 inches by 22 inches. In the base of the furnace is inserted a flat earthen plate, with several indentations, which are, during the smelting, pierced for the outflow of the slag. The blast is supplied through fusible earthen pipes by goatskins plied alternately. When these pipes are burned away, the iron is finished; the base of the furnace is then broken out, the lump of iron extracted, and beaten with hammers to remove the slag, the defective apparatus used obliging them to reheat the iron five times. The smelting operations occupy ten hours, and the

furnace is allowed to cool before being remended for the next charge; each smelting produces about 25 lbs. weight of iron, in the same state as it comes from our own puddling furnaces, with a consumption of 4 tons, 12 cwt. of charcoal per ton of iron; this I have ascertained by experiment, yet in many places can marketable iron be obtained at the rate of £4 16*s* per ton.

The principal iron district is, however, at Chandgurh, at a distance of about thirty miles from Burwayee to the east. The ore here occurs in the altered sandstone rocks (probably the lower beds of the coal-measures); it is a superior quality of red hematite, yielding 63·4 per cent. of metal. The ore occurs in veins and rounded nodules, not unlike our post-tertiary drift. Some of these veins are of enormous size; the river Nurbudda cuts three within the space of a mile, one of them being 122 feet wide—all the purest ore. The rounded nodules are from the disintegration of the metalliferous rocks beneath. All the veins run in the direction of the strike of the sandstone, varying in direction from N. to N. 20° E. The sandstone dips considerably to the east. In the vicinity of the iron district there is a fine supply of magnesian limestone, probably overlying the sandstone unconformably; the latter at the river dipping to the east, and the limestone, five miles south of the river, dipping to the south. I am of opinion that it is a tertiary lacustrine deposit, for in it are many fossils of the family of Lymneadæ.



This is the point where the iron manufacture will be com-

menced, being the centre of a jungle of 20 miles at its shortest radius; wood charcoal will be used until the coal from the Nursingpore coal-field can be brought down by rail, a distance of 150 miles; the country is, however, perfectly flat. To the east of this, for eighty miles, I cannot describe; it is deeply covered by cotton soil, and I passed through it at night. At Sewnee, however, I came upon the coal-measures, and proceeded to Sonadeh, about thirty miles south-east. The Indian Government had there extracted some coal to experiment upon: the section is as follows:—

	Ft.	In.
Sandstone,		(?)
Coal,	1	8
Fire-clay,	1	2
Hard sandstone,	0	2
Thick bedded soft sandstone,	9	0
Shales,	1	8
Coal,	0	9
Carboniferous slate,	0	2
Sandstone,	0	3
Carried forward,	14	5
Brought forward,	14	5
Aluminous shale and sandstone,	0	10
Sandstone with fire-clay,	0	8
Fire-clay,	0	7
Shale,	0	3
Coal,	0	6
Micaceous slate clay,	0	2
Fire-clay,	4	8
Sandstone,		(?)
Total,	22	1

I did not make further delay here, as my time was very limited. But I have no doubt if there were a few deep borings sunk, they would lay open large seams of good quality. As to the coal named in the section, it is a very inferior lignite, having 24 per cent. of earthy matter through it. Some years since great exertions were made to get a good name for it, but it has of late been forgotten.

From this I returned back to the Nurbudda, and came after a few days' march upon the Nursingpore coal-fields at Benar; I found the outcrop of three fine seams of coal, and worked in upon them: the section is as follows:—

	Ft.	In.
Sandstone,	15	0
Shale,	1	0
Coal,	10	0
Fire-clay and shale,	2	0
Sandstone,	18	0
Coal,	6	3
Shale,	1	4
Coal,	3	6
Fire-clay,	2	0
Sandstone,		(?)
	59	1

The dip is 25°, the strike being N. 35° W. The coal is a beautiful lignite, giving 66·88 of coke; it leaves but little residue on incineration, and contains but a trace of sulphur. The country around is flat, and offers every facility to the engineer, and I have no doubt but that one day, the steam-engine, both locomotive and stationary, will be no greater object of wonder to the native inhabitants than the lumbering bullock cart or rustic plough.

The whole country for about 5000 square miles yields two corn crops per year without manure, and cotton is also much grown.

Leaving this district, I proceeded to the city of Jubhulpore. There is an abundance of micaceous iron in its neighbourhood, as also coal. The coal strata, however, stand vertical, and are overlain by a dolomite, similar to that before described, which lies quite horizontal; a fine section is exposed by the river at Kuttee Ghat (see woodcut, p. 184); the effect of it is rather striking.

The river also cuts through enormous cliffs of white marble; about four miles farther down the marble is snowy white and crystalline.

The latter part of my journey was so rapid that my description must be necessarily vague, and allowance must be made for the short time given me for the examination of so large a territory.

November 8, 1854.—"Notice of a Seam of Fossiliferous Limestone in the Millstone Grits of the County of Clare;" by JOHN LLOYD, Esq., C. E.

THE formation which I purpose bringing before the notice of the Society is situated on the west coast of the county of Clare, and consists of alternating beds of arenaceous slate and blue shale. The beds of sandstone vary in thickness from one to three feet, and the shale varies from six inches to thirty feet.

At one point on the coast there is a small seam of coal, varying from two inches to six inches in thickness, and interstratified with the slate rock. The exposed part of the coal being unfortunately at high-water mark, I was unable clearly to ascertain the existence of an underclay.

From the superincumbent rocks, however, I was able to procure

some fossils: they consist of Lepidodendron Sternbergi, and crushed stems, probably Calamites. Several of these latter are prominently exposed by the action of the water.

These fossils, I may mention, are entirely confined to this one spot, not being found in any part of the neighbouring district, a fact which may go to show that this coal seam, with its accompanying fossils, results from drift wood. However, negative evidence is unsafe ground to depend on.

At this point the strike of the rocks is 5° north of west, a strike which is common to the whole district. The dip is 25° south, and the cliffs are here much lower than in any part of the coast near this, being only twenty feet above the sea level.

Not far to the west of the coal there occurs a remarkable band of limestone interstratified between the shale and underlying sandstone.

This band is but eight inches thick, perfectly compact, and terminates abruptly, as shown in the section. The fossils which occur in the limestone show its marine origin, namely, encrinite stems, *Euomphalus pentangulatus*, and one which is rather indistinct, but which may be *Pileopsis vetusta*. The slate rock which occurs below the limestone is identical with that in which the coal fossils occur, and as the fossils which the limestone contains are marine, its occurrence here would appear to show an alternation of sea and land during the portion of the coal period, during which this series was deposited.

This band is the only specimen of limestone which is to be found within twenty miles of Kilkee; the stone for building and agricultural purposes being brought from the Limerick side of the Shannon.

November 8, 1854.—"Notice of the Anthracite found in the Silurian Rocks, in the County of Cavan;" by John Irwine Whitty, LL. D.

Having being called upon to examine the townland of Kill, one mile west of Kilnaleck, in the southern part of the county of Cavan, with a view to determining whether coal might exist there or not, in quantity sufficient to recommend its being worked for economic purposes, I visited that place in the month of April, 1854, and the following is the result of my examination.

The rock throughout this district belongs to the grauwacké formation, the average strike or direction of the out-cropping of the beds is 37° E. of N. by the true meridian; and the dip at the place in question is to the S. E., at about 80°. This is not the true coal formation, as every geologist knows; yet a bed of soft anthracite, or culm, occurs here, about four feet in thickness, in dark-gray clay-slate, having the same strike and dip as the accompanying rocks.

The grauwacké of this part of the country consists generally of beds of strong gray rock, alternating with beds of slate. The thickness of the masses of each kind is very variable, being in some cases a few inches only of slate, or hard rock, and in others from fifty to a hundred feet of either. Some of the hard masses are characterized by containing pebbles, which in general are about the size of peas, but often so much as one or two inches in diameter. The pebbles occur, some round, some angular, and the rock is occasionally massive, showing a total absence of sedimentary lines, or divisions, for several feet together in thickness, and so much altered by metamorphic action, that were it not for the pebbles it might be mistaken for a greenstone. The slate is dark gray and regular where it occurs in thin beds between the harder ones of solid rock; but when it occurs in thick masses it appears much contorted and irregular.

The strike or line of out-crop of the beds of the grauwacké rocks of the province of Ulster is N. E. and S. W., and this direction is, in general, very persistent and regular, but there are local groups in which this strike varies from the general rule a few degrees. The granite which broke up through this formation at Crossdoney, in the county of Cavan, at Slieve Gullion, in Armagh, and at Rathfriland and the Mourne Mountains, in the county of Down, no doubt has had much influence in producing this variation in the strike of local groups of beds. The effect as regards this bed of anthracite is, that though its direction, and the direction of the accompanying strata, can be ascertained with precision in one locality, or in a limited group of the rocks, yet the geologist cannot be certain that it retains this direction in another. Nevertheless, as was said before, the direction of the beds in any group is seldom more than a few degrees from the general direction of the beds of the formation.

A case similar to this, of a bed of culm being found in the grauwacké formation, occurs in Scotland, as reported by Professor Harkness at the meeting of the British Association, in Belfast, in

1852. Professor Harkness states that "at Ruttenside, near Greskin, about four miles above the Beatock Station on the Caledonian Railway, the anthracite is seen in the Evan Water, and this can be traced E. N. E. to Hartfell, and from thence into Peebleshire and Selkirkshire." Again, of the slate which contains it, he says: "This slate extends E. N. E. and W. S. W. It is seen at Stobo, in Peebleshire, and in the summit cutting of the Caledonian Railway, where it shows great thickness. From thence it extends westward through Lanarkshire and the N. E. of Dumfriesshire, to Cairn Ryan in Wigtonshire."

As those Silurian or grauwacké rocks of the Pentland Hills and the south of Scotland are admitted to be the counterpart of our grauwacké rocks in the north of Ireland, or are, in fact, a continuation of the same formation, it is more than probable that the anthracite of the county of Cavan is a production of the bed in Scotland, and extends all the way between them through the counties of Down, Armagh, and Monaghan.

The trial has been made, and culm found in the townland of Kill. Proceeding from this place, the same strike of the rocks produced to the N. E., where it may also be expected, passes through the townlands of—

Drumrath.	Drummanalaragh.
Aghawee.	Portan.
Drumcassidy.	Aghakee.
Druminisclin.	Derry.
Sallaghhill.	Aghavaddy.
Pollareagh.	Lonnog.

And proceeding S. W., next to Kill, lie in the same strike—

Omard.	Ballinamony.
Ardleny.	Killykean.
Losset Killew.	Clonloaghan.
Aghaloory.	Moynagh Lower.
Aghakilmore Lower.	Freeduff.

THE COAL.

The trial consisted in sinking a square pit where indications of coal had been seen at the surface. This pit was at the top about

seven yards long, and five yards wide. In descending, the sides sloped inwards a little, and a bench for casting up the stuff excavated was left at the west side, so that at the bottom it was about four yards long and two wide. The depth was seventeen feet, about four feet of it being clay, and thirteen feet gray slate. The sketch (Fig. 2) conveys an idea of its appearance in this condition. The strong dark line shows the outline of the pit; the part coloured black the anthracite or culm; and *a*, *b*, *c*, *d*, are masses of gray slate included in it. In this view the bed appears to be about four feet average thickness. Fig. 1 is a plan of the pit. Here, also, the black part represents the culm. The chief mass lies in the strike of the slate which accompanies it; it is irregular in thickness, being at the middle part in the bottom above six feet wide, while at *e*, in the S. E. corner of the pit, it diminishes to a string of six or eight inches, as if a crush had taken place, and the soft culm at this narrow part shifted by violence into the bulk or wide part; *b* and *d* are masses of the adjoining clay slate included in the culm; *f* and *g* are spurs emanating from the black mass, and forced at right angles into fissures in the slate.

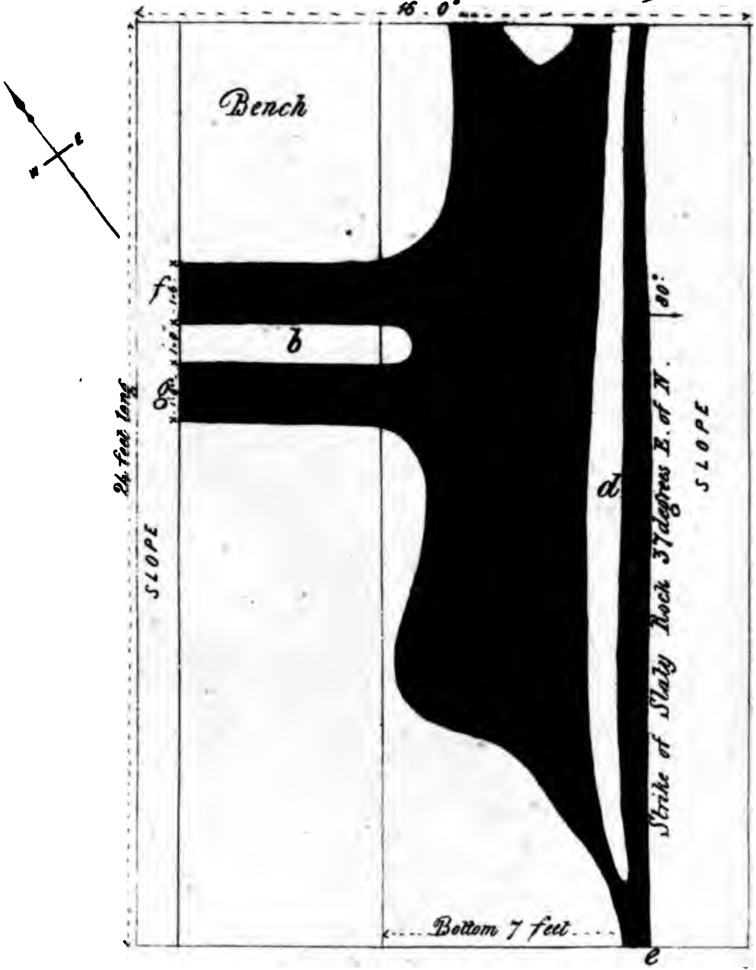
How did those masses of slate get included in the culm?

It appears that this bed of anthracite, soft, and without cohesion, yielded to the influence of the violent earthquake wave which is supposed to have frequently pervaded the crust of the earth in the early periods of its history; and the line of its bed most probably became a line of disruption, in which the culm was broken up and shifted from one place to another. The beds of ordinary slate, or the much harder beds of grit rock, could not yield so easily, and where, in such a line of disruption, pieces of the adjoining slate had been broken off in the tremors accompanying the earthquake, they became, by agitation, enclosed in the soft carbonaceous matter, which thus admitted fragments of the gray slate into its volume, as we now find them.

But this circumstance, of pieces of slate being included in the culm, it is hoped will be found not to exist, or at least not to such an extent in the depth of the mine; as although no doubt the culm is soft at every depth, yet it is not compressible, and by agitation pieces of the slate would not be so likely to be intruded into it below, as in the vicinity of the surface, where it could have easily been shifted in part, or thrown out altogether at the outcrop.

FIG. 1

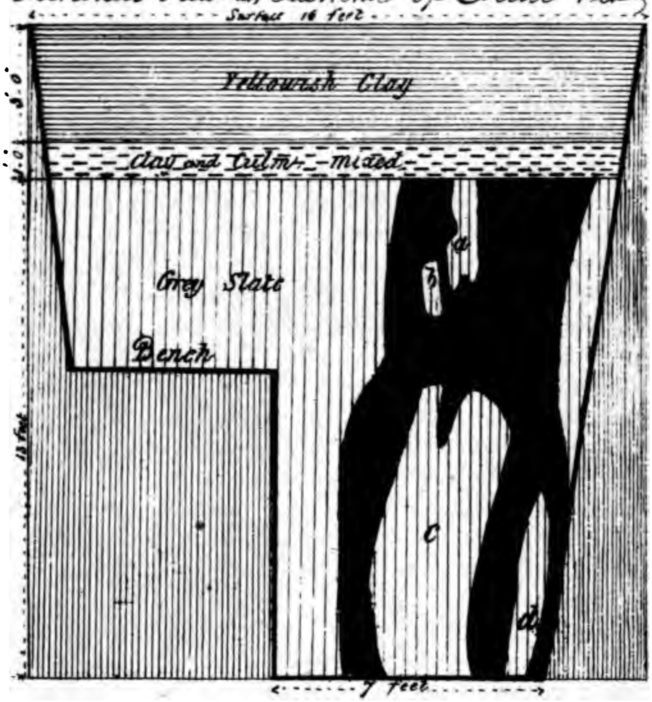
Plan of the Trial Pit



J. I. WHITTY C.E. — LITHO.

FIG. 2.

Sectional View at East end of Trial Pit



Scale to Figs. 1 & 2. 5 feet to 1 Inch

J. I. WHITTY C.E. LITHO.

A specimen of the anthracite analyzed presents the following composition:—

Carbon,	77·64
Water,	4·35
Ash,	18·01
	100·00

It contains no bitumen, and, therefore, is ill-suited for ordinary domestic purposes, but would answer well for burning lime or bricks, and drying malt, when mixed with a small portion of bituminous coal, or turf, to ignite it. Once made red, it gives out a powerful heat, and continues it a great length of time. It will also be found most efficient for smiths' work.

From examination of the whole mass, so far as the pit affords opportunity of observation, I should say that between the walls or sides of the mine which enclose the bed, about one-fourth may consist of masses of slate. This lies in the way, and in working must be brought out as well as the culm, and is of no value; but as the whole contents of the bed can be carried out on a small railroad, in an adit or level driven into it, without any trouble from water, or in lifting, this is no very serious objection; and, as was said before, the proportion of slate in the culm is expected to lessen, or totally disappear, in the depths of the mine.

As a mining speculation, the working of this bed ought to be remunerative and pay well in the county of Cavan, which is nearly all cultivated, and where lime has a wonderfully fertilizing effect on the soil, as in all slate countries, and where fuel is at present too scarce and dear for any but a very limited burning of limestone, which rock is abundant in several parts of the country. A railway is now in course of construction from Mullingar to Cavan, which passes within four statute miles of the place, which will give great facility for the transport of lime or culm to places where it may be required. Culm, differing not much from this in quality, is sold at the collieries near Kanturk, at from eight to ten shillings a ton. Coals from Troon, by a circuitous and expensive carriage, cost at Cavan twenty-five shillings a ton and upwards. These circumstances alone show the great importance of the discovery of a workable coal-mine in this locality.

P 2

THE MODE OF WORKING.

In considering a plan for the working of a colliery two things are especially to be attended to: first, to clear the mine from water; and second, to adopt a good system of ventilation, that the miners may have a competent supply of fresh air.

To work this mine in a general way, the best method would be to commence by adopting means to unwater it effectually, as far as can be done with facility; and for this purpose to select the lowest point in its vicinity as an exit for the water of the mine. This point appears to be at the eastern extremity of Aghaloory, which is 245 feet above the level of the sea. From this point, by means of an open drain for part, and an adit for the remainder, a level could be driven in to meet the coal-bed, and this would unwater all the coal that exists over this level, which increases in some parts to 120 feet in perpendicular height, and would probably average in the entire about 80 feet, taking hill and valley, as they occur, into consideration. But though there is little or no doubt on my mind that the coal exists in the line of the strike of the adjoining rocks, through the country for a considerable distance, and through several of the neighbouring townlands, it has not been discovered yet in the vicinity of this low point at Aghaloory, and, therefore, I would for the present relinquish this project, which could be resumed at a future period if the works on a smaller scale turn out prosperously, as I anticipate, and that it shall be found desirable to work the mine on a larger scale.

I, therefore, for the present recommend, that the works should be confined to the place where the discovery of the coal has been made. From the trial pit to the north-east the adjacent high ground is so situate that levels can be struck at once into the bed, and the coal brought out on a slight railroad, laid in the level, constructed of round iron bars, one inch in diameter, and suitable waggons to carry all the materials excavated to the entrance of the adit. This can be done without any annoyance from water, or expense in lifting the coal by machinery to the surface.

As the sections given on the Ordnance Maps do not follow the direction of the bedding of the rock, but extend from the top of one

hill to that of another, regardless of the strike of the rocks crossing it in every direction, they are unsatisfactory for my present purpose, and, therefore, the amount of coal that may exist in any townland cannot be determined without a careful section made along the line of strike, by means of which the quantity that might be unwatered by drainage alone could be with much accuracy determined; and as to the quantity below the lowest outlet in the depth of the mine, it can be only limited when the expense of unwatering and raising the culm by machinery becomes greater than the value of the culm raised; and this depends so much on circumstances that no estimate can be at present made as to the extent to which profitable working might be carried.

From data taken from the Ordnance Maps in the townland of Kill, the lowest point on the line of strike of the bed of culm is 280 feet above the level of the sea; the hill near the old church is about 360 feet, showing the difference between the highest and lowest points to be 80 feet. From these extremes, and estimates made upon the ground of the other parts, it is not too much to assume that the average height of the bed at the surface, over the lowest point, is 50 feet, and this height can, by means of the adit, be rendered free from water in the operation of mining.

A statute mile in length, 50 feet high, and 4 feet wide, would yield 39,111 cubic yards; assuming these dimensions, and that three-fourths of this could be obtained and sold at eight shillings a cubic yard, it would produce £15,000 for every mile in length along the bed from which, of course, in estimation of net profits all expenses must be deducted.

Fifty feet more in depth below this level would yield the same quantity in the mile, but in this stage, if I may so call it, the value would fall short of the former return by the increased expenditure attendant on the setting up and working of a steam engine and the sinking of a suitable shaft. As was said before, the number of stages, each fifty, or any given number of feet in depth, which it would be prudent to work, would be limited only by the expenses of the machinery, &c., compared with the profit, dependent in a great measure upon the demand which might arise for fuel in that locality.

In the Silurian rocks and the entire grauwacké system, the beds usually dip at a very high angle, showing that flexures have taken

place in this formation to a vast extent, notwithstanding its amazing thickness in the crust of the earth, which some geologists say is 20,000 feet, and others estimate at 30,000 and even more. In depth this bed of culm most probably goes downwards uninterruptedly to a fault or a flexure; but it is impossible even to surmise the depth at which such fault or flexure may exist.

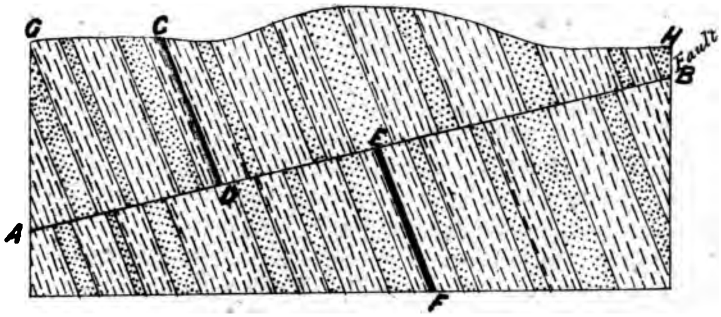
To illustrate this, in Fig. 3, let AB be the line of a fault, and CD a portion of the culm bed in the formation removed along the line of this fault from its original position, where it formed a continuation of EF. At the surface, GH, nothing of this bed can be seen but the outcrop at C; an observer at that point could not, therefore, tell how deep the bed, CD, might descend in a direct line, as there would be no means of determining whether the slip existed on the line AB or not, which could not be ascertained until, in following the work downwards, he should arrive at the point D, where he would find the continuity of the bed to cease abruptly; but science would enable a geologist to determine with probability the direction and extent of the downthrow or dislocation.

Let Fig. 4 represent flexures in the grauwacké formation, the darker shades showing the slate, and the dotted spaces the alternating grit rocks, let C be the bed of culm in the stratification. When such a flexure occurs, which is the general rule in this formation, any bed, C, would go downwards in the earth till it arrived at the bottom of the curve, from whence it would begin to ascend, and probably again reach the surface and lead to the discovery of coal in another locality.

At Fig. 4, C may represent the culm bed and accompanying rocks, which, as stated before, dip to the S. E. at a high angle. The dip of the rock a few miles eastward, between this place and Virginia, is the contrary way, that is, to the N. W., thus indicating at the surface that a flexure exists in the stratification between those places, and of course, that with the other beds the culm may be expected to rise to the surface, dipping the contrary way, somewhere a few miles to the S. E. of Kill, that is, between Kilnaleck and Virginia. The locality of the bed in this part could be very nearly determined by the application of simple geological principles, and a thorough acquaintance with the characters and general arrangement of the grit and slate beds.

Producing the strike of the rock at Kill to the N. E., the grau-

Fig. 3.



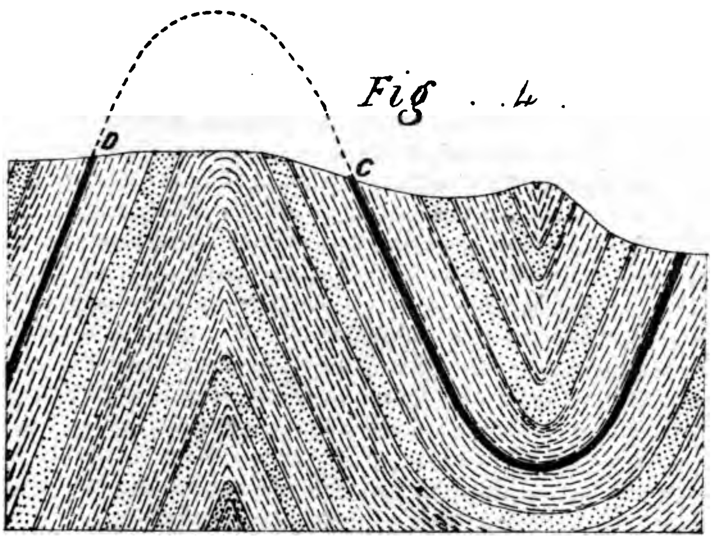
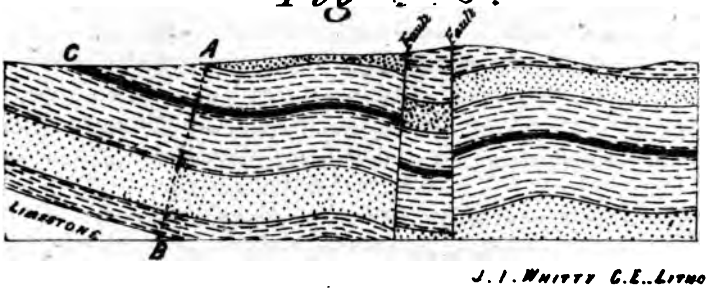


Fig. 4.

Fig. 5.



J. I. WHITTY C.E. LITHO.

wacké formation shows an extensive section across the strike, between Stradone and Cavan, and between Cootehill and Redhill, in which on account of its extent, most probably an anticlinal line, exists, and in this case the bed of culm would be found at the N. W. side of it, in the line of country between the above towns, in manner shown at D, Fig. 4. The upper part of the rocks, between C and D, is supposed here to have been carried away by denudation, and the absent portion of the coal-bed is restored by a dotted line.

In Fig. 5 is represented an ordinary section of the true carboniferous formation, in which alone, by geologists up to this period, coal has been generally sought, and which is known not to exceed one-tenth of the thickness of the grauwacké, where the discovery of the fuel is as yet an anomaly, and which, as it has in an unexpected manner extended our knowledge, will also, it is hoped, stimulate to increased exertion in the mining world. Let AB represent the entire thickness of the coal formation in the carboniferous system, and C a seam of coal with flexures: it will be seen by comparison of Figs. 3, 4, and 5, that in the carboniferous formation the coal-beds lie more conformably with the surface of the earth, and consequently cannot reach to such a depth as the coal I have described in Cavan, in the grauwacké formation, the oldest, and consequently the lowest of all the stratified rocks. The discovery of this bed of coal, in a formation where it was supposed least likely to exist, strengthens my opinion that coal and many valuable minerals exist in this kingdom in abundance, unknown to the proprietors of the soil.* It is likewise my opinion that coal reappears at the surface in other parts of this country in the slate district, and may yet be discovered and rendered a fruitful source of commerce in the country.

December 13th, 1854.—"On the Copper Beds of the South Coast of the County of Cork;" by Richard Griffith, Esq., LL. D., F. G. S. L. & D., &c. &c.

The subject of the present communication will relate chiefly to the metalliferous repositories hitherto worked or discovered in the southern and south-western district of Ireland, situated to the south

* See "Geology of Bearhaven District," and "North Dublin Coal-Field;" by Dr. Whitty.

of the river Blackwater, extending eastward from Millstreet by Mallow and Fermoy to Dungarvan, on the eastern coast; and westward, from Millstreet by Killarney and the river Laune, to Castlemaine Bay on the western coast.

In physical structure the district in question presents a series of nearly parallel mountain chains, affecting a nearly east and west direction near the east coast, but inclining more to the southward as we approach the west, the mountainous character of the district being much more fully developed on the west than near the east coast.

Looking to the west, we find there are four well-defined mountain ranges; and beginning from the north, the alpine ridge of Magillicuddy's Reeks stands pre-eminent, as being the most lofty as well as the most picturesque mountain range in Ireland. It may be said to commence at Fermoy, in the county of Cork, and extend westward by the Bogra, Clydagh, and Mangerton mountains, to the Lake of Killarney, and thence westward the Reeks (proper) commence, the summit of Carntual, elevated 3410 feet above the level of the sea, forming the highest peak; but several other summits of this range reach elevations exceeding 3300 feet.

Proceeding southward, the mountain chain next in importance may be considered as an offshoot from the Reeks, which branching from the Bogra mountains, and, taking a more southerly direction, forms the magnificent ridge of the Esk mountains and Hungary Hill. Still further south, there are two additional ranges, more moderate in character and elevation: one extends westward from the city of Cork, and passing north of Dunmanway terminates at Sheep's Head, between Bantry and Dunmanus Bays, and the most southern extends westward from Bandon, by the Mount Gabriel and Knockmadden mountains, to Three Castle Head, north of Mizen Head, near Crookhaven.

These several mountain ranges are separated from each other by deep and unusually narrow valleys, terminating to the west in sea estuaries; namely, the valley of the river Roughty, terminating in the estuary of Kenmare. The valley of Bantry, terminating in Bantry Bay, and the valley of Dunmanway, terminating in Dunmanus Bay.

The strike of the strata observed both in the mountain ranges and valleys, corresponds with their general direction, namely, about

30° to the south of west, and north of east; and it is observed, on the great scale, that the centres of the mountain ranges present anticlinal axes, and the valleys synclinal axes, which tend to prove that the present physical structure of the country is the result of the last great geological epoch, though, no doubt, the tops of the strata of the valleys have been subsequently exposed to much erosion through glacial as well as ordinary aqueous action. In consequence, a considerable portion of the rocky matter originally contained in the valleys has been removed, and the upturned ends of the strata are exposed to view in the line of strike, both on the north, and south sides of the trough.

In stating that the centre of each mountain chain presents an anticlinal axis, I do not mean to assert that the whole of the strata on the north or south sides inclines, either to the north or south, which is not really the case, owing to numerous minor undulations which occur in the strata, but that in every mountain ridge the strata ascend in the series both to the north and south from the principal anticlinal axis.

The strata which occur in the district thus briefly described consist of portions of the Silurian, Devonian, and lower members of the Carboniferous system.

Those belonging to the Silurian form the nucleus, and generally occupy the most elevated positions; the Devonian rest conformably on them, and descend into the valleys; while the Carboniferous, in the form of troughs, occur only in the valleys near the level of the sea.

Thus the Silurian beds occupy the central portion of the range of Magillicuddy's Reeks, and that of the Esk and Hungary Hill mountains, situate in the north and south of the estuary of Kenmare.

Doubts have been entertained by many geologists as to the propriety of classing these rocks with the Silurian, conceiving that they really form the lowest portion of the Devonian series: but this is a question which need not be considered on the present occasion; as it does not in any degree interfere with the subject now to be treated of. It will be sufficient to observe, that it has been clearly ascertained that the strata, consisting of alternations of chloritic quartzite and purple slate, which have been classed by me with the Silurian system, form the lowest portion of the strata within the

district, and that beds, which undoubtedly belong to the Devonian system, rest conformably upon them. Unfortunately, no fossils have as yet been discovered, and my classification is founded on the position and the perfect identity of these chloritic beds with those which occur in the western extremity of Dingle peninsula, where they are interstratified with and succeed beds abounding in fossils admitted by all geologists to belong to the Silurian system.

Strata which, undoubtedly, belong to the Old Red Sandstone or Devonian system, occur both on the northern and southern declivities of the Silurian strata contained in the two northern mountain chains, within the district under consideration, particularly on the southern margin of Castlemaine Bay, and on both sides of the estuary of Kenmare and Bantry Bay; but further to the south they occupy the central portions of the mountain ridges extending westward from Dunmanway to Sheep's Head, and from Bandon, by Mount Gabriel, to the Three Castle Head.

According to my view, the Devonian system, as it occurs in the counties of Cork and Kerry, consists of a base of compact, coarse red or brownish red sandstone, passing into conglomerate, containing elongated pebbles of white quartz, and more rarely of mica slate; these beds are succeeded by alternations of red quartzose sandstone, and red schistose beds, more or less fine-grained, and passing into red clay slate; and the uppermost part of the series contains frequently thin beds of brownish red limestone, alternating with red slate, and occasionally with gray sandstone and gray slate.

The brownish red limestone indicates the neighbourhood of beds of yellow sandstone, which occur in the low ground adjoining the sea level on the margins of the several estuaries already mentioned; they are succeeded usually by Carboniferous Slate, more or less fully developed; and lastly, by beds of gray limestone, generally impure and frequently siliceous, which resemble in character the arenaceous limestone of the Yellow Sandstone series of the counties of Donegal, Fermanagh, and Mayo.

The limestone beds occupy the highest position in the series of strata, which occur in the district I have been describing, and in every case they are found in the centre of troughs in each of the western valleys; and in this respect they perfectly correspond in position with the limestone which occurs succeeding Yellow Sandstone and Carboniferous Slate in the valleys of the south-east coast,

particularly at Dungarvan, Ardmore, Youghal, Ballycottin, Cork Harbour, &c.

Hitherto I have not alluded to the point at which it may be said the Devonian system terminates, and the Carboniferous begins ; the strata in every case are conformable, and in many the passage from one into the other is so gradual that it is difficult to draw a precise line of demarcation from lithological character alone; in some localities the red slate beds continue, and alternate with a yellow or yellowish gray sandstone, but these yellowish sandstone beds are frequently found to contain numerous plants, which are so perfectly identical with those familiar to geologists as occurring in the upper members of the Carboniferous series, that I have had no hesitation in making this yellow sandstone the base of the Carboniferous system throughout Ireland.

In the northern counties, and particularly in the south-west of Fermanagh, adjoining Lower Lough Erne, and on the north-west coast of Mayo, and other localities, the yellow sandstone alternates with beds of limestone and shale, all abounding in fossils, which clearly belong to the Carboniferous series, and these fossils include marine shells, ichthyolites, and *land plants*, the plants occurring immediately below the fish remains, and above and below the beds which contain marine fossils. No controversy has arisen in regard to these northern strata; but in the south, particularly in the valleys of the counties of Waterford, Cork and Kerry, where the evidence is not so perfect, doubts as to the propriety of making the Yellow Sandstone the base of the Carboniferous in preference to the upper member of the Devonian system have arisen in the mind of our valued geological friend, the President of our Society; in consequence, before committing my views to paper, I made a careful examination of all the fossils I had heretofore collected from the Yellow Sandstone of the southern counties; and I caused an examination to be made within the last month of the Yellow Sandstone troughs at Tallow, Ardmore, and other localities in the county of Waterford: the result of which, together with observations and collections previously made, has so strengthened my former opinion, that I now entertain no doubt as to the propriety of my original classification of the rocks in question, and that they do form the base of the Carboniferous system.

I can now state, as I have already done on several former occasions, that in the south of Ireland generally the lowest members of

the Yellow Sandstone series contain frequently in abundance well-characterized casts of *Sigillaria*, *Stigmaria*, and *Lepidodendron*, with fragments of stems of plants, usually so imperfect as to baffle identification. The latter and the *Sigillariæ* are abundant everywhere; I have collected them from the Yellow Sandstone of Muckross Lake, at Killarney, the banks of the river Roughty above Kenmare, at Blackball Head, Dunmanway, and many other localities too numerous to mention; on the west coast, as well as from the quarries on the north bank of the river Lee, east of Cork, accompanied by *Lepidodendron;* also in numerous places near the east coast of Waterford, where the lowest beds of the Yellow Sandstone contain in abundance casts of the fossil plants already mentioned; and as we ascend in the series, numerous casts of fossil shells and corals are met with, identical with those which occur in the ordinary limestones and shales of the Carboniferous system throughout Ireland, amongst the most characteristic of which may be enumerated:—

Producta	hemisphærica.	Spirifer	concentricus.
,,	semireticulata.	,,	squamosus.
,,	caperata.	,,	imbricatus.
,,	sulcata.	Orthis	crenistria.
Spirifer	bisulcatus.	,,	filiaria.
,,	ostiolatus.	,,	arcuata.
,,	attenuatus.	Atrypa	pleurodon.
,,	disjunctus.	Turbinolia	fungites.
,,	distans.	Fenestella	antiqua, &c.

It now becomes necessary to allude to the discovery of a new species of fern in the strata which immediately underlie the Yellow Sandstone at Glanmire, county of Cork, which I exhibited at the meeting of the British Association held at Belfast, at which meeting our President also exhibited specimens of the same fern collected by the Geological surveyors from the upper portion of the Devonian group at Kiltorcan, near Knocktopher, in the county of Kilkenny, accompanied by a fresh-water bivalve: both of which fossils were considered to be new by the late universally-lamented Professor Forbes, who named the fern *Cyclopteris Hibernica*, and the shell *Anodon Jukesii.* As these fossils were discovered in beds which lie below the Yellow Sandstone as laid down by me, I did not at the time think it necessary to make any particular observations relating to them, but I understood from our President that these fossils had lately been

discovered in localities in the county of Cork, within the limits of the Yellow Sandstone as laid down on the large Geological Map. Should such be the case, and that we find the *Cyclopteris* and the *Anodon* accompanied by such genera as *Stigmaria*, *Sigillaria*, *Lepidodendron*, and other plants, apparently identical with those which occur in the sandstones and shales of the upper members of the Carboniferous series, the natural result will be to include the newly-discovered fossils rather in the Carboniferous series than in the Devonian; any argument founded on their fluvatile origin may be urged equally against the retention in the Carboniferous system of the fresh-water fossils, discovered in limestone at Burdie House, near Edinburgh, or of the *Unio* beds and plants which occur in the coal formation itself. I may also remark, that Yellow Sandstone containing *Lepidodendron* is found to alternate with limestone, and shales in which fish remains, such as *Ctenacanthus*, *Cladodus*, *Psammodus*, and marine shells, occur, on the north coast of the county of Mayo; and that *Sphenopteris linearis*, a well known coal plant, is found in the lower shale of the Yellow Sandstone, in the Banagh River, near Kesh, in the county of Fermanagh.

The foregoing description may perhaps be considered as unconnected with the primary object of this communication, but it should be borne in mind, that the position in which the copper beds of the county of Cork occur, is generally very near to the outgoing of the Yellow Sandstone, as laid down on my Geological Map; hence, in a practical point of view, it becomes most important, that the miner should be made acquainted with the indications which characterize the commencement of that group, as without this clue no direct benefit could be derived from the discovery of the position in which the metallic beds usually occur; but, possessed of this knowledge, walking along the strike of the strata near the outgoing of the Yellow Sandstone, the miner will examine with confidence all the surface indications; and when he observes the bright green tint which the cupriferous beds generally present, he will at once conclude he is on the proper trail.

It was in the year 1819 that I first visited and examined the copper mines on the Audley estate, situated to the south of the village of Ballydehob, twelve miles west of Skibbereen, in the county of Cork.

In the year 1821 I made a second visit, and for several years

subsequently I had several opportunities of visiting and examining the metalliferous repositories of that district.

I shall confine my observations, at the present time, to the metallic beds containing copper and lead, which have been discovered, and partially worked, near the southern coast, commencing at Ringabella, situate to the south-west of the entrance into Cork Harbour, and extending westward from thence by Roaring Water, the Audley mines, and the mines on Skull Harbour to Crookhaven, and I shall take Cappagh as a type of the whole.

The lode in this mine consists of a true metallic bed, composed chiefly of gray clay slate, interstratified with gray quartzite, forming a portion of the Yellow Sandstone series of that locality. The ore is usually contained in a rib, varying in thickness from one to six inches, composed of white quartz, more or less disintegrated, in which purple sulphuret of copper is disseminated.

The bed or lode, which is unusually regular, has a strike nearly east and west by compass, and dips to the south, or, as miners call it, underlies to the south, at an angle of 84° from the horizon.

The thickness between the north and south walls varies from two feet to two feet six inches, and the enclosing walls consist of schistose quartz or quartzite, the rib containing ore lying generally close to the north wall.

In the workings near the surface the ore consisted either of malachite (carbonate of copper), or very rich purple sulphuret of copper, occurring in bunches, intermixed with much white quartz, which frequently traversed the lode in the form of irregular contemporaneous veins, some of which passed into the enclosing walls; but in the twenty-four fathom level, and other portions of the deeper works, the ore occurred only in the form of a regular rib, from two to three inches in thickness, adjoining the north wall, and was composed of purple copper ore, disseminated in small particles through partially disintegrated quartz, and much brown iron ochre, resembling the *gossan* of the Cornish miners.

The lode, or metallic bed, was extensively but unprofitably worked by the Mining Company of Ireland for several years, commencing in the year 1825.

In 1826 the works had been sunk to the depth of twenty-four fathoms, and ultimately to the depth of eighty-four fathoms, and for a length, in an east and west direction, of upwards of sixty fa-

thoms. In some of the upper levels the lode was very regular throughout, but the quantity of ore raised not being sufficient to defray the cost of working, the mine was abandoned, and handed over to the proprietor.

Several other metallic beds, presenting similar characters, were discovered and worked in the vicinity, and in all, the ore raised near the surface was unusually rich, and consisted, as already mentioned, of malachite and purple sulphuret of copper, which, when free from the matrix, produced from 40 to 55 per cent. of pure copper. Near the surface, the ribs containing ore and quartz varied in thickness from three to twelve inches, but in depth they rarely exceeded four inches.

It is unnecessary to describe particularly the numerous localities in this district in which metallic beds producing copper have been discovered, and partially worked, within the last forty years; but the names and localities of the most important are given in the Appendix to this paper. It will be sufficient to observe, that nearly the whole occur within a short distance of the outgoing of the Yellow Sandstone, which on one side occurs resting on the upper beds of the Devonian series, and on the other underlying the Carboniferous Slate; and it is to be observed that the metallic beds occur both interstratified with Yellow Sandstone and Carboniferous Slate, and occasionally within the limits of the Devonian series.

By reference to the large Geological Map, as well as the appended Schedule, it would appear that metallic beds producing copper and lead have been discovered, and many of them partially worked, near the line of the outgoing of the Yellow Sandstone, for a length of sixty miles; or from Ringabella, near the entrance to Cork Harbour, already mentioned, to the Mizen Head. But the most important workings have been confined to the Audley mines, to those on the east and west sides of Skull Harbour, and to the neighbourhood of Crookhaven. Valuable copper lodes have also been discovered, and are at present worked in Carboniferous Slate, adjoining the Yellow Sandstone, on the southern coast of Bantry Bay, particularly at Gortavallig, Killeen, &c., near Sheep's Head; and lodes containing silver-lead at Killoveenoge and Rooska, south-west of Bantry.

As yet, however, our knowledge of this extensive and interesting mining district is very imperfect; and as upwards of twenty years

have elapsed since my original observations were made, which were laid down on an imperfect map of the county of Cork, on a scale of one inch to a mile, the Ordnance Survey not having then been completed, many inaccuracies in the detail must be expected. Hence we may anticipate, at no distant period, much additional scientific as well as practical information from the labours of our distinguished President and his skilful assistants, in regard to the mines and minerals, as well as to the strata and their geological relations, throughout the southern and western districts of Ireland.

SCHEDULE *of Metallic Beds hitherto discovered or partially worked, near the Outgoing of the Yellow Sandstone Series in the South of the County of Cork.*

Post Towns adjacent.	Localities in which the Lodes are contained.	Formation in which occurring.	Observations.
NOHAVAL, ...	Ringabella. Silver lead.	Carboniferous slate.	Has been worked.
CLONAKILTY, . . .	Duneen. Lead and copper.	. . . .	Do.
ROSCARBERRY, . .	The Glandore district—consisting of Keamore, Drum, Rouryglen, and Aghatubrid, &c. Manganese and copper.	Partly in carboniferous slate, yellow sandstone, and Devonian, near the outgoing of the yellow sandstone.	Do.
CASTLETOWNSEND,	Cooscroneen and Rabbit Island. Copper, lead, and antimony; probable extension of the next bed in strike.	In yellow sandstone, and Devonian, near the outgoing of yellow sandstone.	Never worked.
	Bawnishall. Copper.	In Devonian, near outgoing of yellow sandstone.	Has been worked.
BALLYDEHOB, . .	Roaring Water district, consisting of Kilkilleen. Copper and lead. Leighcloon and Laheratanvally. Copper.	In Devonian, near outgoing of yellow sandstone.	Never worked.
	Ballydehob district, Boleagh, Cooragurteen, Skeaghanore, and Derreenalomane. Copper.	In Devonian.	Has been worked.

Post Towns adjacent.	Localities in which the Lodes are contained.	Formation in which occurring.	Observations.
BALLYDEHOB, . . . (*continued.*)	Audley mines, consisting of Ballycumnisk, Cappagh, Horse Island, and Rossbrin. Copper.	In yellow sandstone, carboniferous slate, and in Devonian, near the outgoing of yellow sandstone.	Have been worked.
SKULL, ...	The mines east and west of Skull Harbour, consisting of Castle Island, Coosheen, Gortnamona, Long Island, and Skull, with Castle-point. Copper.	In Devonian, near the outgoing of the yellow sandstone.	Have been worked.
CROOKHAVEN, . .	Ballyrisode, Toormore, Ballydivlin, and Atar. Copper.	In Devonian.	Never worked.
	The Crookhaven mines, consisting of Boulysallagh, Callaros, Crookhaven, Kilbarry, Mallavoge, and Spanish Cove. Copper and silver lead.	Near the outgoing of the yellow sandstone in Devonian.	Have been worked.
	Mizen Head or Cloghane. Copper.	Near outgoing of yellow sandstone in Devonian.	Has been worked.
	On the north-west coast of the parish of Kilmoe, Balteen, Dhurode, Lackavaun. Copper.	Probably in carboniferous state.	Have been worked.
BANTRY, ...	Derreengreanagh. Copper.	Near the outgoing of the yellow sandstone in Devonian.	Never worked.
	Hollyhill. Copper. Gortacloona. Lead.	In Devonian.	Worked.
	Clashadoo, near Dunmanus Bay. Copper.	In yellow sandstone.	Worked.
	South coast of Bantry Bay, Gortavallig, Killeen, Glanalin, and Carravilleen. Copper.	In carboniferous slate.	Worked.
	Killovenoge and Rooska. Silver lead.	In carboniferous slate.	Worked.

December 13th, 1854.—"Geological and Statistical Notes on Irish Mines;" by the Rev. Samuel Haughton, M.A., Professor of Geology in Trinity College, Dublin.

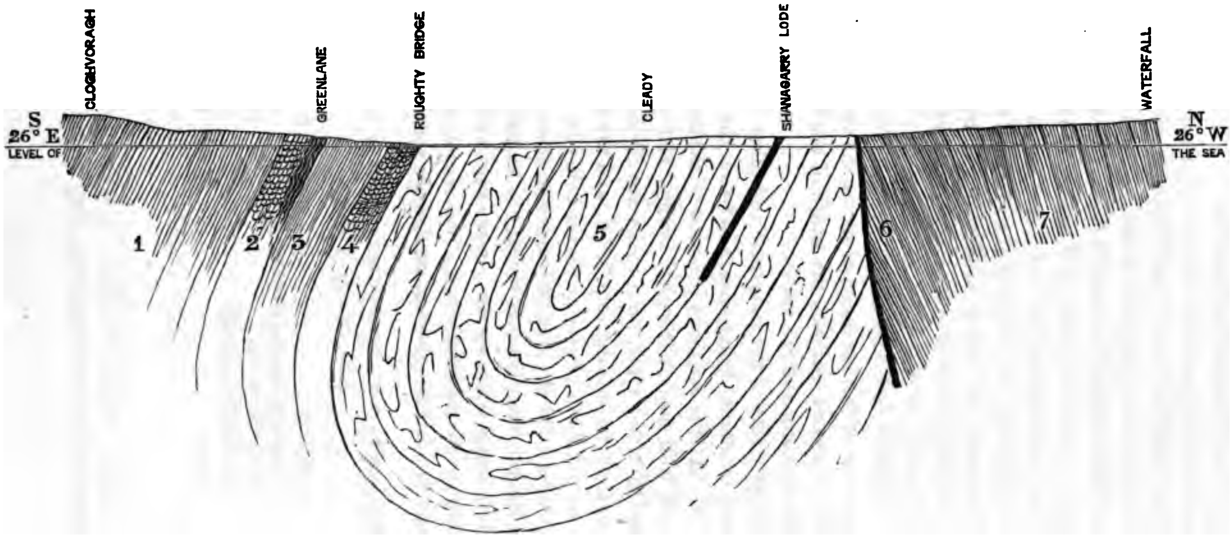
No. III.—Mining District of Kenmare.

In presenting to the Geological Society the third of a series of notes on Irish mines, Professor Haughton wished to state again that his object was, not to attempt a complete account of Irish mines, but to endeavour to collect together a few facts respecting these mines, which had come under his own observation, with the view of preserving a record of a class of facts which were likely to be known only to those immediately engaged in mining operations in this country, and to remain unknown to others, and ultimately become altogether forgotten, unless collected together and placed permanently on record.

Some geologists professed to undervalue the knowledge to be obtained from practical miners, simply because such persons were not accustomed to clothe their facts with the language used by theoretical geologists; and on the other hand, practical miners were accustomed to despise the aid derivable from theoretical geology, because geologists were not acquainted with the class of facts with which the practical miner is conversant from his earliest youth. The reconciliation of these two classes can only be effected by each making itself better acquainted with the facts known to the other, and can never be accomplished, either by pretending to a knowledge we do not possess, or by despising the knowledge possessed by others. When the theoretical geologist enters a mine, quarry, or coal-pit, he should do so as a learner, and not as a teacher, and should be ready to admit that intelligent men who have spent their lives, and made their fortunes, by sinking shafts and driving levels, are likely to know more of such matters than an amateur. On the other hand, the practical miner must and does derive much useful information from the scientific geologist, and would derive much more if the two classes understood each other's language better.

The mines hitherto described by Mr. Haughton have been long and successfully at work, but the present note is a description of a mining valley rather than of a particular mine, and which will require a large outlay of capital and skill before it can be brought

Cross Section of Kenmare Valley to illustrate Rev. Professor Haughton's Paper, page 206.



1, 3, 6, 7. Red and Brown fissile Slate.
5. Carboniferous Limestone occupying the valley in a synclinal fold.
4. Red micaceous Slates and calcareous Sandstones.
2. Band of calcareous Slate of pale colour, containing veins of gray and yellow Copper ore, and green and blue Carbonates of Copper.

Q 2

into full working order, although it already appears to afford promise of becoming an important mining district.

Mr. Haughton proposed to divide the subject of his note into two parts, viz.: the geological description of Glenrough or Kenmare valley, and the mines already at work or being opened up in this valley.

Geological Description of Kenmare Valley.—The valley of Kenmare extends eastward from the town of Kenmare to the village of Kilgarvan, a distance of about eight miles, and varies in breadth from half a mile to one mile. It is formed of a synclinal fold of lower Carboniferous limestone, the fold or bending of the strata having passed the vertical, forming a case of inversion of strata similar to those occurring in the south of Waterford and Cork, in Cornwall, and the Eifel, as described by Sedgwick and Murchison, and other geologists.

In consequence of this inversion of strata, the arenaceous, red micaceous, and calcareous slates to the south of the Roughty, appear to overlie the limestone of the valley.

The average strike of the limestone and other beds in Kenmare valley is very constant, lying always between the limits E. 27° N. and E. 12° N. At the southern junction of the limestone and slaty beds, which is well seen at Roughty bridge, and at a point to the eastward, south of the river, both rocks are divided by two sets of planes: one, the true bedding, dip 70° S., and the other, of cleavage, dip 70° N. to 90°, both classes of planes being intersected by joint planes, making a solid angle of 90° with the cleavage planes.

The position of the planes of bedding is decisively shown in the shaft which is being sunk on the copper vein at Greenlane, where there is a highly characteristic bed of calcareo-argillaceous slate, of which an analysis is here given of an average specimen:—

Calcareo-argillaceous Slate, accompanying Veins of Copper Ore, Greenlane, county of Kerry.

Argillum,	49·25
Peroxide of iron and alumina,	2·03
Carbonate of lime,	38·74
Carbonate of magnesia,	7·83
Water,	1·26
	99·11

It is worthy of remark, that if this limestone consisted only of the pure carbonates of lime and magnesia, they would exist in the pro-

portions of 83·18, and 16·82 per cent., i.e. in the atomic proportion of 4·16 : 1—a composition which, although not that of dolomite, approaches to it.

The mention of these calcareous beds in the micaceous red slate, associated with veins of copper, reminds me of a fact to which my attention was drawn by Mr. Charles P. Cotton, of the occurrence of similar veins of copper ore, in the neighbourhood of Ardmore, county Waterford. On examining Mr. Cotton's section of the limestone and associated beds, at Ardmore, it becomes evident that the copper veins occupy the same position in his section, and my own at Kenmare; and on inspecting and submitting to analysis his specimens of the calcareo-argillaceous rock, in which the copper veins occur, the identity of composition appears as striking as the similarity of position:—

Calcareo-argillaceous Slate, accompanying Veins of Copper Ore, at Whiting Bay, Ardmore, County Waterford.

Argillum,	55·21
Peroxide of iron and alumina,	1·87
Carbonate of lime,	22·31
Carbonate of magnesia,	15·09
Water,	1·92
	96·40

Besides the constituents above given, the rock contained a quantity of green carbonate of copper, in thin sheets disseminated through the specimen. This limestone, if pure, would contain in one hundred parts 59·65 of carbonate of lime, and 40·35 of carbonate of magnesia; being in the atomic proportion of 5 : 4, and thus constituting a true dolomite.

This identification of the copper vein in position would be sufficient, if other evidence were wanting, to prove that the limestone beds of Kenmare valley belong to the lowest group of Carboniferous limestone. Notwithstanding a careful search, several times repeated, I was unable to procure the slightest trace of fossils in the limestone of this district.*

The bedding of the limestone and slate, south of the Roughty, is

* I am informed by Dr. Griffith that he has found in the slate adjoining the limestone in the Roughty valley specimens of *Fenestella antiqua* and impressions of plants.

conformable, and the limestone maintains nearly the same high dip as we proceed northwards, becoming, however, more nearly vertical near its junction with the slate beds on the northern slope of the valley. This junction is not visible, and appears as if it coincided with a line of fault, for immediately north of the junction the slate beds dip to the south at angles varying from 45° to 70°; this opinion is further confirmed by the facts, which will be presently stated with reference to Ardtully mine, a few miles east of the line of section.

The limestone of this district is uniform in character, highly crystalline, and with a slaty structure, exhibiting frequently planes of bedding and cleavage. The inverted beds south of the limestone consist near the junction of a series of micaceous coarse thickly-bedded sandstones, dark-coloured and slaty beds, and calcareous slates, containing nodules of clay ironstone and iron pyrites; and farther to the south than the section extends they are interstratified with thick beds of green grit, some of which are well exhibited in the road cuttings on the way to Bantry from Kenmare. To the north of this section the beds nearest the limestone, and unconformable to it, are soft yellowish slates, with quartzose veins containing micaceous iron in abundance, and under those lie the red slaty beds, denominated "red killas" by the Cornish miner.

Although the limestone of Kenmare valley is in general confined to the narrow strip shown in the section, it is occasionally found in outliers, forming small patches, lying upon the highly inclined beds of red slate; one of these outliers occurs at a point about one quarter of a mile N. W. of Ardtully mine, with a strike N. W., dip, 22° N. E.

Besides the outliers of limestone in Kenmare valley, there are some remarkable boulders, both of limestone and green grit: the most striking of which are the limestone boulders called Cloughvorragh and Carrig-a-Cappeen. The former lies at an elevation of 260 feet to the south of Roughty bridge. I have attempted a rough calculation of its weight, which I estimate at 132 tons. This limestone boulder is covered on one side with shrubs, holly, hawthorn, arbutus, ivy, mountain ash, several kinds of ferns, &c. On the opposite side of the valley, just inside the limestone boundary, occurs the curious green grit boulder, called Carrig-a-cappeen; it is a greenish quartzite, resting upon a pinnacle of limestone, and has the appearance of a large fungus, of which the limestone pinnacle is the stem.

The whole valley near Kenmare is full of these travelled boulders, many of which, particularly the red sandstones, are grooved and striated, as if they had been held while being pushed along a sharp surface, which has cut and polished them.

The Mineral Lodes of Kenmare Valley.—The mineral lodes which occur in this district are lodes of copper and lead, the copper being developed at or near the boundary of the limestone, both north and south, the plane of the lode coinciding *nearly* with the bedding of the slate rock. The lead lodes are confined exclusively to the limestone, throughout which they are developed in several parallel bands, principally, however, near the northern boundary. The lead lodes are, like the copper, *nearly* conformable to the bedding of the limestone, both in strike and dip. This conformability is, however, not complete, either in strike or dip, as will be shown in the description of each lode. I shall describe the lodes in the order of their occurrence, from north to south in the valley.

No. I. *Ardtully Lode—Copper.*—This lode occurs at the northern junction of the limestone and red slate, in the townland of Ardtully, about five miles east of Kenmare. It has been worked to a depth of sixty-six fathoms from the surface, and near the engine shaft has the limestone for its south wall, and the red slate for its north wall; and appears, in fact, to have been formed along the line of fault, separating the limestone from the slate to the north of it. The slate in contact with the north wall of the lode is much softer than at a distance from it, probably owing to the readier percolation of water through the lode. As the lode is traced westward, it leaves the junction of the limestone and slate, and becomes less productive; and it has been found most metalliferous in that portion of it which lies between the limestone and slate. The width of this lode varies from three to ten feet, and is conformable to the strata ; it consists of a series of smooth polished sheets or secondary walls lying within the main walls. The south wall of the lode does not come into contact directly with the limestone, but is separated from it, as the north wall is separated from the red slate, by a remarkable black shining slate, coated with fibrous streaks of a mineral resembling some of the hornblendes, and this black slate forms the north and south walls of the lode.

The direction of the lode is very nearly due east and west; it underlies south, for forty fathoms, about two feet in six; it then

becomes vertical for sixteen fathoms, and ultimately acquires a small underlay to the north.

The ore varies considerably in character and quality, but consists principally of argentiferous arsenical gray copper, of an ordinary specimen of which an analysis, made by Mr. Corrigan, in the Laboratory of Trinity College, is here given.

Analysis of Gray Copper Ore from Ardtully Mine.

	Per Cent.	Atomic Quotients.		
Silica,	5.29			
Sulphur,	25.32	1.582		13
Arsenic,	16.07	0.214	0.243	2
Antimony,	3.70	0.029		
Copper,	40.26	1.270	0.896*	7
Iron,	4.54	0.162		
Zinc,	3.18	0.098		
Silver,	0.15	0.001		
Sulphuret of Mercury?	0.56			
	99.07			

From this analysis we may deduce the rational formula,

$$7RS + 2QS_3;$$

in which

$$R = Cu_2, Fe, Zn, Ag.$$
$$Q = As, Sb.$$

This formula approaches the well-known formula for Fahlerz

$$4RS, QS_3,$$

with which it would coincide, if there were eight atoms of basic sulphurets instead of seven.

In addition to the gray ore just described, the purple or horseflesh copper ore, and the ordinary yellow ore or copper pyrites, occur; particularly in the deeper levels. A cross course of calcaceous spar intersects the lode near the engine-house, underlaying west, and with a direction N. 17° W. This cross course does not appear to heave the lode, which, however, becomes poor to the eastward of the cross course, and is particularly rich at the intersection westward.

* Found on the supposition that two atoms of copper are isomorphous with one of iron, zinc, or silver.

No. 2. *Forge Lode—Copper.*—At a distance of 108 fathoms, south of the Ardtully lode, there occurs another lode of copper, which has not yet been much worked; it lies altogether in the limestone, and so far as it has been worked, contains exclusively horseflesh or purple copper ore; its direction is parallel, or nearly so, to that of the Ardtully lode.

No. 3. *Shanagarry Lode—Lead.*—The Shanagarry lode lies in the limestone, at a distance of about 130 fathoms from its northern boundary. It is being worked at two points, at Shanagarry and Cleady. The direction of this lode is accurately E. 22° N., and it is very nearly, but not quite, coincident with the strike of the limestone in which it occurs; the strike of the latter being E. 17° N.

This lode has been worked at Shanagarry, by the Lansdowne Mining Company, on a pipe vein, to the depth of 42 fathoms from surface; it underlies for 30 fathoms about 2 feet in 6, when it becomes more perpendicular, and the rock also is softer. The average dip of the lode is 70° S., and of the limestone, 75° S. The metalliferous part of the lode lies in sheets between thin partings of limestone and dips with them, but seems at intervals, as for example in the 39 fathom, to cut through the limestone sheets to the south, reappearing in other beds further south.

Near the surface this lode produced considerable quantities of iron pyrites and blende, but in the bottom levels, the argentiferous lead-ore is free from these substances.

At Cleady a shaft has been sunk to the depth of 10 fathoms, by the Trinity Mining Company, on the course of the same lode, 620 fathoms west of Shanagarry, in very favourable ground, containing iron pyrites in abundance, with leaders and occasional large stones of lead ore.

No. 4. *Shanagarry South Lode—Argentiferous Lead.*—This lode has been opened at a point called Crean's Shaft, south-east of Old Shanagarry Castle, and is 63 fathoms south of Shanagarry lode, to which it is parallel in direction; and it has been traced westward to a distance of more than a quarter of a mile across the River Cleady; it contains a considerable quantity of blende, mixed with the argentiferous galena.

No. 5. *Killowen Lode—Argentiferous Lead.*—Proceeding southwards, we next come to the Killowen lode, which lies due east and west (magnetic), and has been traced from the road opposite Kil-

lowen House to the garden belonging to Kenmare Chapel, close to the town, a distance of one statute mile; it contains iron pyrites and veins of lead at Killowen, and a promising vein of lead at the garden near Kenmare. This lode is about 285 fathoms south of the main Shanagarry lode; it does not appear to have been developed to the extent which its importance would seem to require.

No. 6. *Trinity Lode—Copper.*—This lode lies in the red micaceous slates, south of the Roughty, and is accompanied by the remarkable beds of impure magnesian calcareous slate, described at p. 208; it was first discovered at Greenlane, on the College property, and has since been traced westward to Kenmare suspension bridge, a distance of 2½ miles. At Greenlane a shaft has been commenced, on the underlay of the lode, in which purple and gray copper ores have been discovered. The ore at the north side of Kenmare bridge, in this lode, consists of copper pyrites, which has been found near Cromwell's fort, in sufficient quantity to promise a return for a judicious outlay of capital.

No. 7. *Trinity South Lode—Copper.*—This lode runs E.W. (mag.) parallel to the Trinity lode, and at a distance 38 fathoms south of it; it has been traced from Greenlane to Kenmare bridge (south side), at which latter place a rich bunch of gray ore has been discovered.

The seven lodes just described are the principal lodes hitherto discovered in Kenmare valley, and none of them have yet been worked on a scale sufficient to develop their resources. Of these lodes, four are copper, and three lead; the copper lodes occurring two and two, at the northern and southern junctions of the lower carboniferous limestone with the underlying red slates and sandstones; the lead lodes are confined exclusively to the limestone, while the copper lodes, particularly on the south side, occur in the underlying calcareous slates. It is worthy of remark, in speculating on the position of these copper lodes, to observe that they occur in the same geological position as some of the best lodes in Ireland; for instance, the Gurtnadyne lode at Silvermines, and Bearhaven mine, county of Cork, which latter mine may, in fact, be considered as occurring in part of the same valley, and in the red slates south of, and older than, the Carboniferous limestone of Kenmare valley.

December 13th, 1854.—"On the Limestone Troughs of Ardmore and Lismore, County of Waterford;" by Charles P. Cotton, Esq., C. E.

Mr. Cotton presented to the notice of the Society two sections: one across the synclinal trough of limestone which ranges from Youghal to Ardmore; and the other across the band of Carboniferous limestone running from Lismore to Dungarvan.

The two sections are much alike, being sections through limestone valleys and the adjoining sandstone hills.

These limestone valleys are of frequent occurrence in the south of Ireland, three at least occurring within a few miles of one another in the county of Waterford.

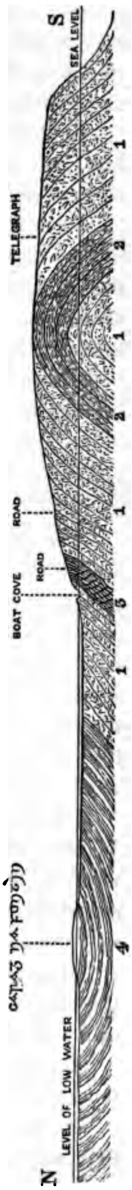
These valleys or bands of limestone run in a direction nearly due east and west, and are, for some distance, nearly uniform in breadth.

The limestone at its junction with the sandstone is conformable with the latter, and always forms a synclinal axis; in some cases the beds having been so much tilted over as to give the appearance of being older than those they support.

The annexed section at Ardmore runs nearly due north and south across the headland of Ardmore, and across part of the bay. The beds of sandstone which form the headland present as curious an instance of contortions as occurs anywhere.

In this section, Carboniferous limestone is represented by 4; Carboniferous slate by 1, 1, 1, 1, the junction being occupied by sandstones, 3; and 2 denotes the Cupriferous calcareous slates described in p. 209.

At the southern end of the section the beds dip towards the sea, and, proceeding northwards, form on the whole an anticlinal axis, dipping into the sea again at the Bay of Ardmore. Not far from the junction with the limestone, I found some fossils, which appear to be a kind of fern, for which Mr. Haughton has proposed the provisional name of ***Filicites dichotoma.*** In one speci-



men of these fossils the branching shape is very well shown, but, generally speaking, they occur so confused and broken, that it is not easy to get any distinct idea of their shape. Farther from the junction with the limestone I found traces of them in blue slate, but this material appears to be much less favourable to their preservation.

In this sandstone are several traces of metallic ores, copper and lead, the ores of copper being green and blue carbonate and gray copper; that of lead, galena.

Some mines were formerly worked at Ardmore Head, and some of the shafts still remain. The ore occurs in a gangue of quartz and slate. Though the sandstone contains quartz veins running in all directions, I did not notice any trace of ore in any but those that occurred between two beds of stratification.

In the limestone which occurs at Ardmore, I noticed the following fossils:—

Favosites megastoma.
Lithodendron cæspitosum.
Platycrinus costellatus.

The drift which covers the limestone, and in some places the sandstone, is curious as containing numerous pieces of trap and porphyry, in some cases consisting entirely of these rocks, but generally mixed with sandstone pebbles. I remarked about the drift, that while the sandstone pebbles were rounded by attrition, the trap stones were very sharp on the edges, but in the shingle of the beach the trap stones which occurred were perfectly rounded; from which it appears that the trap had been deposited there without much previous attrition.

I may also mention a curious boulder which lies in a field near Whiting Bay: it at first has the appearance of a conglomerate, but when broken appears made up of concretionary siliceous nodules, containing often chlorite in the centre; it is unlike any rock in the neighbourhood.

The section near Lismore runs also north and south, and crosses the band of limestone which meets the sea at Dungarvan. The locality of the section is about one mile west of Cappoquin.

On the south the section commences in a range of hills which separates the valley of the Bride from that of the Blackwater.

At the junction of the sandstone and limestone, the sandstone, at first sight, appears to be newer than the limestone, and to overlie it; but in reality it is a case of an inverted synclinal axis.

The sandstone at this end of the section is, as far as I could see, without fossils.

The limestone that the section passes through is very compact, and without fossils.

On the north side of the river the rock is for a short distance limestone, but the limestone on this side of the river is of small extent, and, I believe, hitherto unnoticed.

Passing the limestone, we meet alternating beds of blue slate, grit, and sandstone.

In this latter, the sandstone, I found some fossil plants, which resemble crushed flaggers. They are not abundant, being confined to one small quarry.

Near Salterbridge House, where the junction of sandstone and limestone occurs, are large pits of bog iron ore, not recently worked, and near the same spot in the sandstone occurs a good deal of micaceous iron ore. The rest is destitute of ores, except a small trace of galena in the limestone.

Fluor spar occurs in very small quantities, accompanied by lead in one quarry.

December 13th, 1854.—"Note on the Carboniferous Limestone of Midleton, County of Cork;" by WILLIAM J. WELLAND, Esq., C. E.

MR. WELLAND presented a section of the limestone which ranges from Cork to Midleton. This section, which is somewhat more than four miles in length, runs north and south from the townland of Ballyspillane to that of Scariff. Commencing in a range of hills composed of Old Red Sandstone, it runs to a parallel range of the same formation, passing through the intervening valley, which is filled up with mountain limestone. Some of the quarries in this limestone are very rich in fossils; in one of them I found the following:—

Midleton Limestone.

Amplexus coralloides.	Spirifer bisulcatus.
Fenestella laxa.	" disjunctus.
Fenestella membranacea.	" speciosus.
Orthoceras laterale.	Productus rugatus.
Atrypa acuminata.	" antiquatus.
" hastata.	" concinnus.
" pugnus.	" corrugatus.
" fallax.	Reticularia imbricata.

At the northern junction of the limestone and sandstone there is a band of Yellow Slate, in which I obtained the following fossils :—

Midleton Slate.

Fenestella antiqua.	Spirifer bisulcatus.
Atrypa fallax.	„ speciosus.
Athyris concentrica.	„ sulcatus.
„ squamosa.	„ disjunctus.
„ Roysii.	Orthis filiaria.

I did not observe a corresponding band of Yellow Slate at the southern junction, but it possibly exists; indeed, that at the northern end has been only rendered visible at this spot within the last few years, being exposed by the cutting necessary for a new line of road; but I believe it had been previously observed in the neighbourhood.

January 10, 1855.—"On the Occurrence of Sulphate of Barytes in the South West of the County of Cork;" by THOMAS DAWSON TRIPHOOK, Esq., C. E.

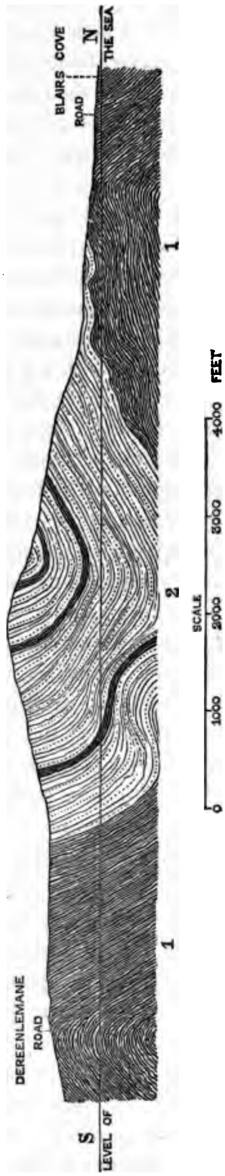
THE south-western portion of the county of Cork has been long known as a highly mineralized district; consequently one need scarcely expect to find any mineral the component parts of which, if at all possessing any commercial value, which is not known at least by name even amongst those who make no pretensions to acquaintance with the rudiments of mineralogy. Moreover, this district has been most carefully examined by the Cornish miners, whose perseverance and aptitude for observation is very evident from the numerous mines, pits, and open casts which meet the geological observer in every direction. Amongst those minerals possessing commercial value, one of the most recently discovered is the sulphate of barytes, a mineral chiefly brought before the public attention by the advertisements of the venders of "genuine white lead," who one and all protest against the use of this mineral for the purposes of adulterating the former. The uses and abuses of the latter I shall shortly advert to.

The locality in which the principal lode of sulphate of barytes occurs, which shall chiefly form the subject of this paper, is situated between the Bays of Dunmanus and Roaring Water, county of Cork, and, as is usually the case in the mineral districts of this county, occurs on a hill side; it has a watershed of about 300 acres, admirably

adapted by its position at the head of a valley for water-power, for six or eight months of the year, sufficient for pumping, winding, and crushing.

The blue, green, and gray slate, or grits of the old red sandstone, are the constituents of this geological formation occurring in this district; also large quantities of peat. This latter occurrence may yet, perhaps, be of more importance than is at first apparent in connexion with sulphate of barytes.

The accompanying section, from Blair's Cove to Dereenlemane, will illustrate the stratification of this district. 1, 1, blue and purple slates ; 2, green grits and slates.



The observations of the various angles of dip on the southern side of the section are easily effected both in the blue and green series; on the northern, with some difficulty, although a considerable extent of the surface of the rock is exposed, showing alternations of the blue or purple and green rocks and shales; still the amount of section is insufficient, in most cases, to distinguish the cleavage and joints from the dip with certainty, even on the coast line, particularly amongst the purple slate.

Amongst the minerals occurring in this district, in addition to the sulphate of barytes, will be found glance copper, copper pyrites, and purple ore, with green carbonate of copper, bog-iron ore, carbonate of iron, iron pyrites, chlorite; also impressions, apparently vegetable, in the soft gray killas, in the immediate proximity to the main lode of sulphate of barytes. These minerals, however, are chiefly the components of the copper lodes. I shall therefore pass on to the mode of occurrence of the lode of sulphate of barytes.

One of the first circumstances noticed by

an observer is the coincidence of the old county road with the run of the lode, which bears about N. 45° W. This coincidence, it is easy to see, arises from the desire to take advantage of an opening in the hill in which the lode occurs, to secure the lowest level for the road; and secondly, that this lode intersects the east and west copper lodes, of which there are three, if not more, which occur within fifty or sixty fathoms of each other, running with the strike of the rock E. 5° N., as is usual with the copper lodes of the district, and underlaying 70° N., the sulphate of barytes lode underlaying 70° W. From this description it is evident that the latter is the counter lode of miners; thus far the geologist can observe at surface.

From the difficulty arising from the concealment of the rock by the soil, as well as from deficiency in the amount of section of the rock when exposed rendering observation rather doubtful, little more information could be obtained. It is otherwise on inspection of the underground operations in progress on the lode, when it becomes at once apparent that the formation of the sulphate of barytes, on whatever theory it may be explained, has been contemporaneous, or perhaps subsequent, to the formation or occurrence of a fault, and also of a heave or lateral movement of the ground on one side at least; this side, in my opinion, being the western. I am also inclined to believe that this movement, and probably contemporaneous eruption of the sulphate of barytes, took place subsequent to the formation of the copper lodes. And firstly, it will be found on examination that the western side of the fault has been heaved to the amount of twelve feet at least towards the north; this is seen from the occurrence of a lode of copper pyrites and sulphate of barytes intermixed at the shaft, though not to be observed at surface; also from the disturbance of the strata, as seen in a shaft on a late discovery of a large extent of lode within ten feet of surface. The continuity of the beds being broken by the barytes lode at this place, one cannot fail to observe, that whereas the hanging wall of the barytes lode is completely broken and crushed by the lateral movement, on the contrary, the foot wall is remarkably hard and smooth, as though rendered so by the movement of the hanging wall upon it just previous to the injection of the sulphate of barytes, which is, I believe, now supposed to have been deposited from solution, and which in this case was just sufficient to fill the chasm to the then surface without overflowing. This is evident from the fact

that there is no flow of the barytes such as might be expected to have resulted from the pouring out of the solution, and its subsequent induration after deposition in the manner of lava (unless it has been removed by subsequent denudation), to be found near the lode or elsewhere. The cleavage of the foot wall, which in the undisturbed strata, remote from the action of the movement, is parallel to the strike of the rocks, is, at its coincidence with the lode, turned or curved towards the north, while that of the hanging wall is turned south, being a further indication of the direction of the movement. That the copper and barytes lodes are not contemporaneous formations is, I think, sufficiently clear from the fact that only such spots of purple copper ore and green carbonate of copper are found in the barytes lode as might reasonably be expected to have dropped into the chasm at the moment of its formation. I have also observed, that while the true copper lodes adjoining the barytes are composed of yellow ore or copper pyrites, the specks of ore in the barytes lode are invariably either purple copper or red copper ore, which at first sight may easily be mistaken for the peroxide of iron or gossan usually accompanying the copper lodes.

As regards the continuity of the barytes lode on the horizontal and vertical planes, as well as uniformity, or otherwise, in breadth, there is still room for investigation. It will be seen that it possesses all the characteristics of a true lode, such as regular underlay, regular and well-defined walls, and the invariable accompaniment, no matter how small it may thin out, of a leader or thread of ore, or at least, of a peculiar "freedom," of a white colour; also the occurrence of a spring of water.*

On the north side of this set the lode has been traced by trial pits close to the boundary, taking a rather irregular course, yet still not deviating but by short curves or waves from its general bearing: for reasons I need not dwell upon it has not been thought desirable to continue these trial pits to the extreme northern boundary. I shall, therefore, briefly mention the method adopted in ascertaining its bearing in a southerly direction, as far as it has been

* An east and west lode has been traced for a short distance, at the depth of five fathoms, branching off the main lode; and at its junction a large bunch of ore was raised; it probably has been the result of a splitting of the fissure, but has not been sufficiently explored to enable the observer to form on opinion as to its probable extent.

explored. For this purpose I may state a few of the indications rendering the exact position of the lode a matter of almost certainty. Firstly, its bearing in a position already explored; this, however, though of much importance, would not answer every case, because, as I have already mentioned, the lode deviates from a right line; and secondly, the lode thinning out to a mere string, which would not repay the trouble of driving on. It therefore was found by experience that the most economical and easiest, and consequently the plan adopted, was to put down open casts at right angles to the known bearing of the lode, at short distances asunder, until the rock in every instance was met with,—the exact position of these pits being determined, as before, partly from the bearing of the rest of the lode, from springs, from float ore or small rounded pebbles of the sulphate of barytes brought down by winter floods, thus indicating the proximate existence of the lode, these pebbles being water-worn, and embedded in alluvial soil and peat, as well as from angular pebbles of the sulphate of barytes, showing a still closer proximity; also from the configuration of the ground, and particularly in places where the alternations of blue and green slates were frequent; and from the position of the copper lodes, at the junction of which, with the barytes, large bunches of the latter were generally found. On the other hand, those places in which the blue slate appeared unbroken and continuous were known by experience to be unproductive. The run of the lode is shown by the strong red line on the map. As yet the trials extend to the south as far as a small stream, which, however, must have cut the lode, from the quantities of pebbles of the ore it has brought down; the appearance of the portion of the lode at present under mining operations from its abundant yield of very superior quality of ore, not requiring immediate and further surface exploration.

I shall now mention a few peculiarities in the mode of occurrence of the lode. One of the most remarkable is its opening from a mere thread in the horizontal plane to a breadth in several places in the solid of from 9 to 12 feet, independent of a soft flookan on the hanging wall, varying from 4 inches to a foot in thickness, carrying along with it a broken mass of shale and soft killas, making up a breadth frequently of 14 feet, and then contracting in the same manner. These great cavities, now filled with ore, extending on an average breadth of 6 feet for upwards of 6 fathoms

in length, and in depth, though sometimes gradually increasing, at the rate of 6 inches in a fathom, to a depth sometimes of 10 fathoms, and carrying this breadth down, never decreasing or closing as in the horizontal plane; and usually, when the lode is discovered poor at surface, it continues so in depth, and *vice versâ.* These great bunches frequently contain a portion of the adjacent rock, termed by the miners a horse, which, of course, when of any considerable size, deteriorates the value of the lode, more especially when it is considered that in these large gashes or chasms the expense and difficulty of timbering is greatly increased,—to such an extent that the lode, or rather the portion of ground which must be removed, becomes so unmanageable as to preclude the possibility of driving the levels preparatory to stoping away the backs and placing the stull pieces so as to insure the success of future operations. This will be evident from what has been already mentioned, viz., a jointed lode of 12 feet wide in the solid, resting on a smooth and hard foot wall, offering little or no resistance to sliding, the wall standing at an angle of 70°. This alone would require much care and judgment in removing, but when to this is added the accompanying difficulty of a hanging wall unsound for 3 feet further,—both to prevent the risk of loss of human life which would probably be occasioned by heavy falls from the jointed roof, as well as the unknown expense sure to attend the crushing of the stulls and the closing of the walls in case of a run,—it becomes necessary to carry down the lode from the surface by an open cutting between firm walls, and when these are doubtful, securing the ground by long continuous wall-plates and propping pieces, to be afterwards removed and saved on placing the stull pieces, which are intended both to afford room for working away the next slope, as also to carry the mass of rubbish, necessary for keeping the ground from closing, which is, on the removal of the ore, filled in for that purpose. These stull-pieces, varying from 12 to 16 feet long, are usually of bulk or whole timber, of 12 or 14 inches square, and in this locality are generally procured from the ribs of broken-up or wrecked vessels, generally costing less than half the price of new yellow pine of same dimensions, provided that the timber is sound.

The timbering of a mine like this being a troublesome process, requiring the services of a careful and experienced miner, is a fruitful source of cost to the adventurers, which, with the perhaps equally expensive alternative of securing the ground by arches of masonry,

cannot be obviated. Whether the latter alternative would be less expensive is to be questioned, inasmuch as masons accustomed to the risk and habits of miners would most probably be required for the purpose. At the immediate junction of the copper and barytes lodes, the latter becomes discoloured from the iron contained in the former, and moreover presents a hard and unprofitable substance, made up chiefly of quartz-chlorite and sulphate of barytes mixed, striking fire abundantly to the pick; consequently, it is most desirable, in selecting a position for a shaft, to avoid that particular spot, which, however, is seldom more than three or four feet wide; but on driving, again gives place to the pure sulphate of barytes, which in this lode occurs only in the amorphous state. I have not succeeded in finding a single crystal amongst many hundred tons, although crystalline structure is frequently to be met with. Well-shaped crystals of iron pyrites are to be found on the back of one of the copper lodes of the pentagonal dodecahedral form, the copper pyrites occurring uncrystallized.

Having thus endeavoured to show the manner in which the sulphate of barytes occurs in this locality, I may observe that in two places distant from the lode under description, about two miles on the south and west respectively, the same ore occurs to the south, in the immediate vicinity of a copper mine, its bearing being in this case parallel to the east and west copper lode, its colour of an impure white, and of a very crystalline structure; that to the west is a lode running north and south, underlaying west, of a very pure white colour, and uncrystalline; also, near the town of Bantry, on the north-east side, occurs a great lode of this mineral, of a very pure colour, although associated with micaceous iron ore, running across the strike of the rocks, and may be traced at surface for nearly a quarter of a mile in length. This mineral is also found to the west of Bantry, and is found and worked near Clonakilty in this county.

The mode of working the lode, by sinking, driving, and stoping, is similar to that usually practised in working copper lodes; horse-whims and tackles are found to answer effectually for raising the ore, without expenditure on machinery when sent to market in the crude state; that raised in lumps requiring no preparation, and that in smalls requiring one washing and picking. The price of the ore in the crude state varies from 24*s.* to 32*s.* per ton in Liverpool; when crushed to an impalpable powder, fetches from £4 to £5 per

ton, according to quality, its value depending mainly on its purity and whiteness for the purposes to which it is applied. The process of removing the stains of iron by the action of diluted sulphuric acid is effected at the cost of about 10*s*. per ton. I am informed that in Glasgow alone "1000 tons are annually consumed by colour-makers to mix with white lead; by paper-makers, to make their paper white and heavy; by printers, to make their calicoes shine brightly, and for other purposes." Its uses, on the small scale, in the laboratory, are well known, all the salts of barium being easily obtained from the sulphate. Mr. Dana mentions that the nitrate affords a yellow light in pyrotechny, and that the prepared carbonate is used for a water-colour; also, that in the preparation of Venice, Hamburgh, and Dutch whites, the sulphate, when of a pure white, gives greater opacity to the paint. The other principal markets for this article are those of Liverpool and London; it is generally sent to the latter in the manufactured state. It is to be hoped that other and more important, as well as more legitimate, uses may be found for this mineral, now found so abundantly in this country, than those of mere adulteration. The late Mr. Westgarth Forster, in his valuable "Treatise on a Section of the Strata in Cumberland," thus describes this mineral:—"It is commonly a dull, ill-looking spar, frequently rising in globes and irregular masses, and so exceedingly heavy that miners have always imagined that it contained metal, only they think that the proper flux for it is not discovered. No doubt, this mineral body is replete with the vitriolic acid, which the art of the chemist may extract; at the same time there is reason to believe it highly probable that it is not the ore of any useful metal." Liebig, in his "Letters on Chemistry," written some time after, speaking of the sulphur monopoly in Sicily, says:—"In gypsum (sulphate of lime), and in heavy spar (sulphate of barytes), we possess mountains of sulphuric acid. As the price of sulphur rose, men began to think of obtaining the sulphur of these minerals for commercial purposes; the problem was, how to render them, in the cheapest way, available in the manufacture of sulphuric acid. Hundreds of thousands of pounds weight were prepared from iron pyrites while the high price of sulphur consequent on the monopoly lasted; we should have probably ere long have triumphed over all difficulties, and have obtained sulphuric acid from gypsum. The impulse has been given, the possibility of the process proved, and it may happen in a few years that the inconsiderate financial speculations

of Naples may deprive her of that lucrative commerce." Should such a source of sulphuric acid be ever resorted to, the quantities of peat in this country may perhaps be brought to bear in converting the sulphate of barytes to the sulphuret of barium, amongst other "uses to which turf might be applied in Ireland." However, as this subject has been so ably treated in Mr. Sullivan's "Journal of Industrial Progress," I merely mention this suggestion in the hope that those well acquainted with the proposed chemical problem for the conversion of the sulphate of barytes from as yet a comparatively insignificant into the most valuable of all commercial products,—sulphuric acid,—may be induced to consider the subject in its more special relation to the development of the deposits of peat, so abundant and so much neglected in this country.

January 10, 1855.—"On the Composition of the Feldspar of the Dublin and Wicklow Granite;" by the Rev. J. A. GALBRAITH, M.A., Professor of Natural and Experimental Philosophy in the University of Dublin.

As the Geological Society have on some former occasions done me the honour to record in their Proceedings analyses which I have made of Irish minerals, I beg leave to present a series of seven analyses of feldspar, taken from different localities in the Dublin and Wicklow Mountains.

	Dalkey.	Three Rock.	Lough Bray.	Lough Dan.	Glenmacanass.	Glendalough.	Glenmalur.	Average Composition.
	Sp. gr. 2·540	Sp. gr. 2·562	Sp. gr. 2·554	Sp. gr. 2·559	Sp. gr. 2.553	Sp. gr. 2·453	Sp gr. 2·560	Sp. gr. 2·540
Silica, ...	64·00	65·40	65·44	65·05	64·19	63·60	64·48	64·59
Alumina, ...	18·11	17.71	18·36	17·72	18·39	18·84	19·04	18·31
Magnesia, ...	0·57	1·77	0·00	trace	0·34	0·40	1·02	0·58
Lime, ...	trace	trace	0·80	0·23	0·70	trace	trace	0·25
Potash, ...	12·73	10·68	12·34	13·42	11·39	14·33	10·74	12·23
Soda, ...	3 ·00	3·26	2·73	2·75	2·95	1·92	2·64	2·75
Loss by Ignition, .	0·55	0·69	0·52	0·36	0·58	0·60	0·78	0·58
	98·96	99·51	100·19	99·53	98·54	99·69	98·70	99·29

Although these analyses have been already published in the Proceedings of the Royal Irish Academy, yet as a contribution to the data necessary for determining the chemical constitution of the rocks of this range, I have no doubt they will prove of some interest to the Society.

January 10, 1855.—"On the Evidence afforded by Fossil Plants, as to the Boundary Line between the Devonian and Carboniferous Rocks;" by the REV. SAMUEL HAUGHTON, M. A., Professor of Geology in the University of Dublin.

THE drawing of a boundary line between different geological periods is a problem which becomes more difficult in proportion as our knowledge increases. The divisions made by nature in geology are seldom abrupt, and it is, therefore, often difficult to systematize our knowledge, and compel the various groups of rocks we meet with to range themselves in rank and file under the heads of our book-made systems.

We are assisted mainly in our efforts to draw these boundary lines by two principles:—

1st. When two groups of rocks are unconformable, provided this unconformability is not merely local, we are entitled to draw the boundary line between them.

2nd. When one or other of two groups of conformable rocks do not contain fossils, we draw the line of separation at the point where the fossil remains commence or disappear.

Both of these methods of making geological distinctions are liable to exceptions, which are well known to every practical geologist; but in general it is safe to adhere to these broad principles until it is shown that the case considered is a real exception to the rule.

In attempting to draw a line between the Lower Carboniferous and Upper Devonian rocks in Ireland, Dr. Griffith, and most Irish geologists, have adhered to the second principle above laid down, and, in the absence of truly characteristic Devonian fossils, have drawn the boundary line at the base of the fossils which extend some distance below the true Carboniferous limestone, into the divisions known as the Carboniferous Slate and Yellow Sandstone of Dr. Griffith.

Until it is shown that this palæontological division is erroneous, by proving that it includes typical Devonian fossils in the Carboniferous system, we cannot accept in its place a merely lithological division, which would leave, both above and below the boundary line, typical fossils belonging to the same geological period. These principles I regard as so obvious, and so generally received, that I shall not waste the time of the Society by further enforcing them, but shall proceed to my task of examining the fossil plants of the lower fossiliferous beds, in order to ascertain whether it is possible to draw

a line separating them into Devonian and Carboniferous; and if the result of that examination should be, that no such line can be drawn, then we are entitled, in accordance with the second principle laid down, to draw the boundary line at the base of the fossiliferous beds.

Some geologists of reputation are of opinion, that the first introduction of land plants on the earth took place at the close of the Devonian and commencement of the Carboniferous period; and explain the occurrence of anthracitic and bituminous beds in the Silurian rocks of Ireland, Scotland, and Russia, by the hypothesis, that they are the result of accumulations of marine plants.

As this question was one of some interest, I undertook lately the chemical examination of the ash of the anthracite, described by Dr. Whitty as occurring, in the county of Cavan, in Silurian slates.

For the purpose of comparison, I have placed beside my results the results of two specimens of ash of Newcastle coal, examined by H. Taylor, Esq.:—

	GOOD NEWCASTLE COAL. Ash = 1·36 per cent.	IMPURE NEWCASTLE COAL. Ash = 16·90 per cent.
Silica,	59·56	64·21
Alumina,	12·19	28·78
Peroxide of Iron,	15·96	2·27
Lime,	9·99	1·34
Magnesia,	1·13	1·12
Potash,	1·17	2·28
Soda,	—	—
	100·00	100·00

SILURIAN ANTHRACITE, COUNTY OF CAVAN.

Ash = 4·28 per cent.

Silica,	71·43
Alumina and Peroxide of Iron,	19·81
Lime,	0·43
Magnesia,	1·34
Sulphate of Potash,	0·28
Sulphate of Soda,	0·23
Sulphates of Lime and Magnesia,	1·22
Alkalies in combination with Silex; Carbon; and Loss,	5·26
	100·00

It is not possible from the preceding results to draw any inference as to the origin of the Silurian anthracite; the ash appears to have a chemical composition similar to that of the slates in which it occurs, as has been observed by Mr. Taylor with respect to the ash of several varieties of coal examined by him; and as the further examination of the amount of alkalies, contained in the last item of the analysis, did not promise any result of geological value, I did not think it worth while to examine the total quantity of alkalies in the ash, as the undetermined alkalies were in combination with silica, and most probably derived from the slate in which the coal was embedded. I may add, that it was exceedingly difficult to burn this anthracite, and that a superficial examination of it would almost lead an observer to confound it with some varieties of plumbago, for which it has, I believe, been mistaken by some. This incombustibility would seriously diminish its value as a fuel, in an economic point of view, as it would require to be mixed with large quantities of more inflammable and porous fuel, in order to admit of being used to advantage.

Returning from this digression to the immediate object of my present communication to the Society, I would observe, that whether the opinion just alluded to, as to the time of the first appearance of land plants, be adopted or not, it is certain that at the close of the Devonian and commencement of the Carboniferous periods, there was a considerable development of vegetable life, which is the more remarkable from the absence of fossil land plants in the older rocks. This development of vegetable life has been observed in almost every country where the boundary of the Devonian and Carboniferous rocks has been studied with any degree of care; among others, I may mention Saxony, the Rhenish provinces, the Bas Boulonnais, Devonshire, Scotland, and Ireland (*passim*).

I shall take a few of these districts in order, and shall examine what assistance their fossil plants afford us in drawing a line between Devonian and Carboniferous rocks:—

1. In Thuringia and Saxony the labours of the German geologists, Richter and Unger, have resulted in the discovery of two distinct Floras, one, Upper Devonian, and the other, Lower Carboniferous. The Devonian Flora of Thuringia, which occurs with the characteristic *Cypridina schiefer* of German geologists, is described by Professor Unger as consisting of Ferns of new and undescribed genera, and

even of new families, together with plants intermediate between Ferns and Equisetaceæ, and primitive forms of Cycads and Conifers, of which he says no one has yet had an idea. On the other hand, the Carboniferous Flora contains a totally distinct group of forms, which are highly characteristic of the lower Carboniferous beds. Among these are mentioned:—

Calamites transitionis.—*Göpp.*
Calamites cannæformis.—*F. A. Römer.*
Megaphytum Hollebenii.—*Cotta.*
Knorria (several species).
Noeggerathia Rueckeriana.—*Göpp.*

These geologists have adopted this remarkable distinction of Floras as the principle of their subdivision of Thuringian and Saxon rocks into Devonian and Carboniferous, and the result of the adoption of this principle has already been a great extension of the territories of the lower Carboniferous period.

2. In the Rhenish provinces of Prussia, where the Devonian rocks are typically developed, this remarkable Devonian Flora has not been, so far as I am aware, as yet observed; but the lower Carboniferous Flora is extensively developed, containing the same plants as in Thuringia, and never descending into the typical Devonian beds.

3. In the Bas Boulonnais, in France, there is a remarkable group of lower Carboniferous beds, which have been described by Mr. Austen and Mr. Sharp. These beds have been considered by successive observers as Silurian, Devonian, and Carboniferous, but there is no doubt at present as to their true position; they are Carboniferous, descending in their lowest members into the disputed territory between Carboniferous and Devonian. I believe them to be altogether Carboniferous, in proof of which it is almost sufficient to mention that the very lowest beds in the district contain the well-known Carboniferous fossils:—

Terebratula ambigua;
Terebratula pleurodon;
Spirifer disjunctus;
Cyrtia laminosa;
Orthis resupinata;

and do *not* contain the characteristic Eifelian fossils of either the upper or lower groups.

Immediately above the limestone and dark shale, containing these

fossils, occurs a micaceous sandstone, with impressions of Ferns and Calamites, in such abundance as to have caused many fruitless searches for coal. Above the plant beds is found the Cucullæa bed of sandstone, containing the same fossils as the Marwood beds of Devonshire, above which again are found the usual characteristic lower Carboniferous fossils. The position of the fossil Flora of Bas Boulonnais is clearly established in the lower Carboniferous beds; the only arguments against this view being the occurrence of the Cucullæa beds above the plants, these beds having been considered as Devonian. But it must be remembered that the Marwood beds in Devonshire are themselves obscure, and should rather be interpreted by the Boulonnais beds than *vice versâ*. In the Boulonnais the Cucullæa sandstone lies between beds containing Carboniferous fossils, and no characteristic Eifelian fossils, and must, therefore, be considered as itself Carboniferous, and with it the Marwood beds of Devonshire. This view of the subject has been advocated by Mr. Sharp, whose only difficulty in considering the whole group as Carboniferous appears to be the occurrence of a few corals of Devonian type; but these very corals I have shown to occur abundantly in the Carboniferous beds of the Menai Straits, which have not been classed as Devonian by any geologist.

4. In a paper read by me before this Society, in November, 1853, I described a succession of 1730 feet of Carboniferous rocks at the Menai Straits, and came to the conclusion that there was no sufficient reason for considering the lower part of the series as Devonian, although there did occur in it some corals of Devonian type. These corals are specifically identical with the corals of the Boulonnais; but, like these, they occur with such an overwhelming number of Carboniferous fossils, that the whole series must be considered as Carboniferous. Of the 1730 feet of rocks, the lowest 80 contain remains of fossil plants in such abundance as to have led, as in France, to a considerable expenditure in search of coal. Among these plants the most common is a very long crushed stem, with narrow flutings, which would have been pronounced a Calamite but for the absence of joints; it should probably be referred to the genus Sigillaria, which is developed in Ireland, in beds of the same age, in a remarkable manner.

5. In Devonshire, near Marwood, a group of fossil plants has been found in Sloly Quarry, occurring in beds of the same age as the

Cucullæa sandstone of Marwood, at the base of the Carboniferous and top of what is commonly called the Devonian system,—a name which, it may be observed, is singularly ill chosen, as there is no district in Europe whose geology requires more interpretation than Devonshire and Cornwall.

These fossil plants have been examined by Professor Lindley and Professor Henslow, the former of whom considers that many of them may be referred to the genera Stigmaria and Lepidodendron; one is referred to the genus Sternbergia; and another is probably identical with *Calamites Volzii*, of Brogniart, from the obliquity of its articulations. One of the fossils is described by Mr. Lindley as having on one side the impression of a *Lepidodendron*, and on the other side it is striated like *Calamites arenaceus*. This remarkable appearance is referred by Mr. Lindley to accidental juxtaposition of two fossils; but in some of the Irish plants, of the same age, the same appearance is repeated under circumstances which render it impossible to refer it to accident.

According to the final judgment of Mr. Lindley, all the genera are referable to genera of the Coal period, but he hesitates to identify the species. Professor Henslow agrees in opinion as to the difficulty of identifying the species. Whatever opinion may be formed as to the age of the beds of S. Devon, it will readily be admitted that the Barnstaple and S. Petherwin beds, immediately below which the Cucullæa sandstone of Marwood and these fossil plants occur, are still open to question, as to whether they should be referred to the lower Carboniferous or the Eifelian type; and, in my judgment, the balance of evidence lies in favour of the former opinion; it is certainly very remarkable to find such a uniform development of fossil plants, at precisely the same period, through the whole of western Europe.

6. Considerable interest has been recently excited by the discovery of a land reptile, the *Telerpeton Elginense*, at Elgin, in Scotland, and also the occurrence of land plants in beds of the same age at Lerwick, in the Shetland Isles. Some of those plants, according to Dr. Fleming, bear a remote analogy to compressed stems of Sternbergia, and others, according to Dr. Joseph Hooker, may be referred to two distinct species of Calamites. The absence of articulations is noticed by him as a remarkable feature, and in two specimens he observed transverse raised knobs or bars, perhaps spirally arranged,

crossing the striæ obliquely. These fossil plants occur in the gray sandstone, or uppermost beds of the red sandstone of Scotland, in precisely the same geological position as the other plant beds already described.

Irish Plant Localities of the Yellow Sandstone Group.—Having thus described rapidly the occurrence of a remarkable group of fossil plants in a similar position at the base of the Carboniferous formation in other countries, I shall now proceed to mention the manner in which the same group of plants occurs in Ireland. We owe to Dr. Griffith the observation that fossil plants mark everywhere through Ireland the base of the Carboniferous system. This fact was known to him many years ago as a practical rule in working the boundary beds between the Carboniferous rocks and the rocks lying under; but, so far as I am aware, no attempt has been made to describe the fossil plants of the lower Carboniferous beds of Ireland, and accordingly, I gladly availed myself of Mr. Griffith's permission to examine his cabinet, and describe, as far as his specimens and some others in the Museum of Trinity College would allow of accurate description, the obscure but interesting remains of this primeval Flora.

1. One of the best collections of fossil plants, from a single locality, of this age, hitherto found in Ireland, is, I believe, the collection made by the Geological Survey, under the direction of our President, in the neighbourhood of Knocktopher, county of Kilkenny. It includes new species of Cyclopteris, and some varieties of Stigmaria, Calamites, and Lepidodendron.

With these plants occur some remarkable fresh-water shells of the genus Anodon, and some fish and crustacean remains, a description of which, and of the entire group, may shortly be expected from the palæontologists of the Survey.

I am informed by our President that sandstone beds, which contain species of Cucullæa identical with those of the Marwood beds of North Devon, occur above the plant-bearing beds of Knocktopher, which, it will be remembered, is analogous to the relation of the Cucullæa and plant beds in the Boulonnais and Devonshire. These plant beds occur just outside the boundary of Mr. Griffith's yellow sandstone, and it must be considered, from the analogies I have mentioned, as an open question whether they shall be considered as lower Carboniferous or upper Devonian.

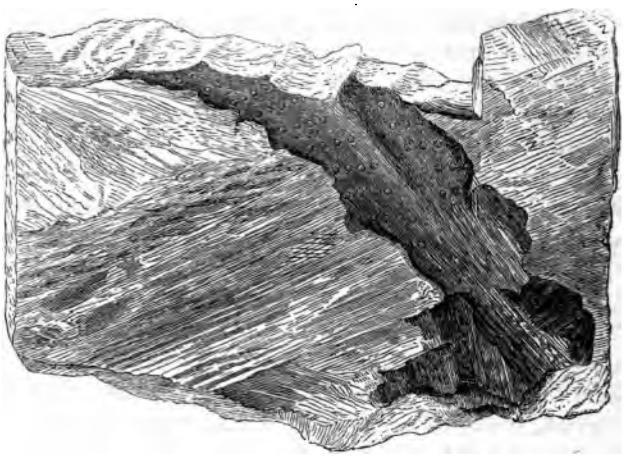
2. In the slaty and sandy beds underlying the synclinal axis of Carboniferous limestone at Tallow Bridge, county of Waterford, both to the north and south of the basin, a rich collection of fossil plants occurs, among which the following are the most remarkable:—

1. Lepidodendron Sternbergi.—*Ad Brong.*
2. Stigmaria (ficoides?)
3. Sigillaria dichotoma.
4. *Filicites dichotoma.*
5. *Lepidodendron minutum.*

The first of these plants, although the impression is obscure, I have little doubt is correctly named *L. Sternbergi*, and is specifically identical with the well-known plant of the coal-measures.

The Stigmaria is not identical with *S. ficoides*, from which it differs in the fact of the stigmata lying closer to each other than in *S. ficoides.* Measured in one direction, there are nine stigmata per inch, and in the other direction, nine stigmata in two inches.

I have named *Sigillaria dichotoma* a very remarkable and abundant fossil, which occurs in lengths sometimes of six feet, and which would be taken for a Calamite were it not for the want of



SIGILLARIA DICHOTOMA, from Tallow Bridge, county of Waterford, showing the bifurcation of the stem and the circular, spirally arranged, stigmata.

articulations. A perfect series of this plant has been formed by me from the specimens in Dr. Griffith's collection, in which the passage may be traced from the large, finely striated, dichotomous Sigillaria

stem to the small dichotomous branches known to me previously under the provisional name of *Filicites dichotoma.* The *Sigillaria dichotoma* is characterized by the fineness of its flutings, which I have not found exceeding six to the inch. This character renders it specifically distinct from any Sigillaria of the coal-measures. The stem dichotomizes regularly, each branch being half the undivided stem. When the stem is 3 in. diameter, the flutings are 13–14 to the inch; when the stem is $1\frac{1}{4}$ inch diameter, the flutings are 16–17 to the inch.

As the carbonaceous matter of the stem is wanting in the Tallow Bridge specimens, no markings of the leaf scars remain on the stem, except small circular punctures, which are arranged spirally in such a manner that the distances of the punctures or stigmata from each other in the spiral are *half* the distances between the spires: e. g., in a stem 1·2 in diameter, the vertical distance between the successive spiral rows is 0·27 in., while the distance of the stigmata from each other in the spire is 0·13 in., and the angle made with the horizon by the spire is 35°.

The *Filicites dichotoma,* which is a very common fossil plant, at the base of the Carboniferous series in many parts of Ireland, is only the upper and delicate branches of the *Sigillaria dichotoma.*

Lepidodendron minutum, and Sigillaria dichotoma, from Tallow Bridge, county of Waterford, showing the former to be the cortical covering of the small branches of the latter.

The plant named by me provisionally *Lepidodendron minutum,* there is good reason to believe to be the true coating of the *Sigillaria dichotoma.*

This remarkable specimen recalls the observation of Professor Lindley on the Devonshire Lepidodendron.

3. A synclinal trough of Carboniferous limestone runs from Lismore to Dungarvan, from beneath which the slaty beds rise up, towards the north and south. At the south side, near Lismore, *Sigillaria dichotoma* and *Filicites dichotoma* have both been found; and on the north side, near Dungarvan, the *Sigillaria dichotoma* has been observed.

4. In a similar synclinal trough at Ardmore, county of Waterford, both *Sigillaria dichotoma* and *Filicites dichotoma* have been found in abundance in the beds underlying the Carboniferous limestone.

5. The synclinal trough of Carboniferous limestone on which the city of Cork is built stretches to the east and west of that city. At Midleton, on the east and north of this limestone, *Sigillaria dichotoma* has been found in the beds underlying the limestone, and on the banks of the river Lee, in a similar position, to the westward. Along this line, at Glanmire, the *Cyclopteris Hibernica* has been found.

6. A synclinal trough of Carboniferous limestone, similar to those already mentioned, passes from Cloyne to Carrigaline; in the neighbourhood of the latter place *Sigillaria dichotoma* has been found in the beds underlying the limestone.

The position of the beds just described, from 2 to 16 inclusive, is under the Carboniferous limestone, but still belonging to the Carboniferous period, as may be easily seen by referring to any list of fossils, from the slaty beds underlying the limestone; e. g. Mr. Welland's list of slate fossils from Midleton.

7. Near Bantry, fossil plants resembling those found at Knocktopher and Glanmire have been found in a similar position by the Government surveyors.

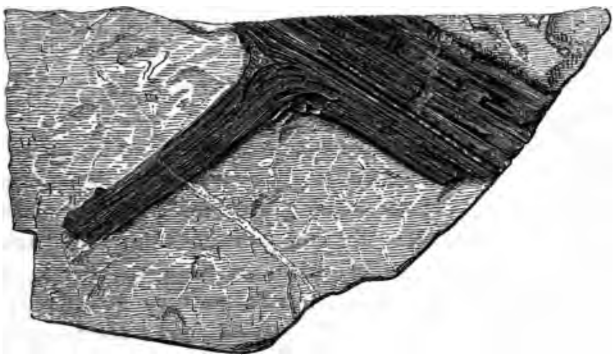
8. In Kenmare valley, near Roughty Bridge, *Sigillaria dichotoma*, associated with *Fenestella antiqua*, has been found, as stated by Dr. Griffith; and also in Brickeen Island, near Killarney, in the corresponding band of yellow sandstone, north of the Reeks.

9. At Cultra, county of Down, near Belfast Lough, a remarkable group of plants has been found in the beds classed by Dr. Griffith with the yellow sandstone series. The following occur abundantly :—

Stigmaria ficoides.
Lepidodendron (*new species.*)
Sternbergia approximata.
Calamites (*new species*), resembling a delicate variety of Cal. transitionis, *Göpp.*
Sigillaria (*new species*).
Filicites Cultranensis.

The first and third of these plants are well known in the coal-measures. The Calamite is a new species, and identical with a Calamite found in the calp beds of Clontarf, county of Dublin.

The *Filicites Cultranensis* I have named provisionally, until better specimens than those I have examined be found. It is identical with a plant found in the calp beds of the Naul, county of Dublin, which is here figured.



Filicites Cultranensis, from the Naul, county of Dublin.

The plants of Cultra occur in beds containing the marine shell *Kellia gregaria*, and the *Holoptychius Portlocki*, together with the characteristic *Modiola Macadami*, and species of *Ctenacanthus*, *Chelyophorus*, and *Cythere.*

10. At Dromard and Moyheland, near Draperstown, county of Londonderry, in the yellow sandstone band stretching from Newtownlimavady to Magherafelt, the *Sigillaria dichotoma* occurs with its characteristic spirally arranged punctures, which have been taken by some geologists for varieties of Spirorbis. With this plant is associated the *Filicites dichotoma*, which I believe to be identical with it, and the shells *Modiola Macadami* and *Atrypa gregaria*, with *Holoptychius Portlocki.* At Fallowgloon, near Maghera, in the same county, the *Sigillaria dichotoma* also occurs.

11. At St. John's Point, near Dunkineely, county of Donegal, a Calamite, n. sp., occurs, with characteristic Carboniferous mollusca and corals. Its articulations are oblique.

12. In the yellow sandstone beds which run north-east from Lower Lough Erne, near Pettigo, Calamites and other undermentioned plants have been found associated with *Modiola Macadami* in the same group of rocks; at Drumcurren, near Kesh, the highly characteristic coal plant *Sphenopteris linearis* occurs with *Holoptychius Portlocki.*

13. In the remarkable patch of yellow sandstone, on the borders of Leitrim and Longford, at Cloone, near Drumcorry, a *Lepidodendron*, n. sp., and *Lepidophyllum lanceolatum*, have been found associated with *Stigmaria ficoides.* These plants also occur at Monaduff, associated with *Modiola Macadami*, the *Oracanthus Milleri*, *Ctenacanthus*, and other fish remains, for which that locality is celebrated.

14. The last Irish locality to be mentioned is the typical yellow sandstone district of North Mayo.

Near Ballycastle, *Lepidodendron Sternbergi* occurs associated with species of *Ctenacanthus*, *Psammodus*, *Cladodus*, with *Atrypa gregaria*, *Modiola Macadami*, and about one hundred other Carboniferous fossils.

In the same district, on the shore of Lackan Bay, at Kilcummin, *Sphenopteris linearis*, identical with the Kesh specimens, occurs abundantly, and at Larganmore, near Bangor, numerous fossil plants occur in connexion with *Modiola Macadami* and a plant not known to me, but which bears a resemblance to some varieties of Knorria described by German geologists.

The fourteen distinct Irish yellow sandstone localities which I have enumerated, containing a group of fossil plants, of which many are identical with plants of undoubted Carboniferous age, when compared with the other six localities described, afford the strongest presumption that the beds in which these plants occur should be classed with the Carboniferous deposits, and that in Ireland the base line of the lower Carboniferous period should be placed below the entire group of plant beds.

As the fossil plants have been given in the order of localities, it will be of use to append to this method of viewing them a Table showing the localities in which each plant is found, arranged in the order of the plants themselves.

NAME OF PLANT.	LOCALITY.	GEOLOGICAL PERIOD.
1. **Stigmaria ficoides,**	Cultra, Down.	Yellow Sandstone.
	Cloone, Leitrim.	„ „
2. **Stigmaria,** (new species),	Sloly Quarry, near Marwood, N. Devon.	Yellow Sandstone.
	Tallow Bridge, Waterford.	Carboniferous Slate.
3. **Lepidodendron Sternbergi,** *Ad. Brong.* Sagenaria dichotoma, Geinitz.	Tallow Bridge, Waterford.	Carboniferous Slate.
	Passim.	Coal-measures.
4. **Lepidodendron** (undescribed species),	Cultra, Down.	Yellow Sandstone.
	Cloone, Leitrim.	„ „
	Ballycastle, Mayo.	„ „
5. **Lepidophyllum lanceolatum,**	Cloone, Leitrim.	Yellow Sandstone.
6. **Sigillaria** (undescribed species),	Menai Straits.	Yellow Sandstone.
	Cultra, Down.	„ „
7. **Sigillaria dichotoma,**	Tallow Bridge, Waterford.	Carboniferous Slate.
	Lismore, „	„ „
	Dungarvan, „	„ „
	Ardmore, „	„ „
	Midleton, Cork.	„ „
	River Lee, „	„ „
	Carrigaline, „	„ „
	Kenmare Valley, Kerry.	Yellow Sandstone.
	Brickeen Island, Killarney.	„ „
8. **Filicites dichotoma,**	Tallow Bridge, Waterford.	Carboniferous Slate.
	Lismore, „	„ „
	Dungarvan, „	„ „
	Ardmore, „	„ „
9. **Filicites Cultranensis,**	Cultra, Down.	Yellow Sandstone.
	The Naul, Dublin.	Middle Carb. Limestone.
10. **Calamites Volzii ?** *Sternberg.*	Sloly Quarry, Marwood.,	Yellow Sandstone.
11. **Calamites arenaceus ?**	Sloly Quarry, Marwood.	Yellow Sandstone.
12. **Calamites transitionis,*** *Göpp.*		
13. **Calamites cannæformis,** *F. A Rœmer.*	Liebschwitz, Saxony.	Jüngste grauwackenschichten.
	Taubenpresseln, „	„ „
	Leoboschütz, Silesia.	„ „
	Tost, „	„ „
	Landeshut, „	„ „
	Altwasser, „	„ „
	Bogendorf, „	„ „
	Clausthal, Harz.	Jungere grauwacke.
	Wernigerode.	„ „
	Magdeburg.	„ „
	Eimelrod, Upper Hesse.	Posidonia schichten.
	Herborn, Nassau.	„ „
	Falkenberg, Glatz.	Carboniferous Limestone.
	Ebersdorf and Berthelsdorf, in Saxony.	Aeltere Kohlenformation.
	Bristol and Newcastle.	Coal-measures.
14. **Calamites Cultranensis,**	Cultra, Down.	Yellow Sandstone.
	Clontarf, Dublin.	Middle Carb. Limestone.
15. **Calamites** (undescribed species),	Ferques, Bas Boulonnais.	Yellow Sandstone.
	Lerwick, Shetland.	„ „
	Bruckless, St. John's Pnt.	„ „
	Pettigoe, Donegal.	„ „

* I believe this plant to be the same as the *Calamites cannæformis* of Römer, and only a variety of the *C. cannæformis* of Lindley and Hutton.

NAME OF PLANT.	LOCALITY.	GEOLOGICAL PERIOD.
16. **Noeggerathia Rueckeriana,** *Göpp.*	Liebschwitz, Saxony. Leobschutz, Silesia. Bogendorf, " Friedersdorf, "	Jungste grauwaucke. " " " " " "
17. **Sternbergia approximata,**	Cultra, Down. Passim.	Yellow Sandstone. Coal-measures.
18. **Sternbergia** (new species).	Sloly Quarry, Marwood. Lerwick, Shetland.	Yellow Sandstone. " "
19. **Megaphytum Hollebenii,** *Göpp.*	Saxony and Silesia.	Red and Green schists of the Jungere grauwacke.
20. **Knorria** (various species),	Saxony and Silesia. North coast of Mayo.	Red and Green schists of the Jungere Grauwacke. Yellow Sandstone.
21. **Undescribed species of Ferns,**	Ferques, Bas Boulonnais.	Yellow Sandstone.
22. **Cyclopteris Hibernica,** *Forbes.*	Kiltorcan, Co. Kilkenny. Glanmire, Cork. Bantry, Cork.	Yellow Sandstone. " " " "
23. **Sphenopteris linearis,**	Kesh, Fermanagh. Lackan Bay, Ballycastle, Mayo.	Yellow Sandstone. " "

NOTE of a few Remarks made by MR. GRIFFITH in the Discussion ensuing on PROFESSOR HAUGHTON'S Paper.

IN the Carboniferous system in Ireland there are three analogous regions or groups in which plants having a striking typical resemblance occur, namely, beginning from the top:—

1st. In the Coal series.

2nd. In the Calp series, interposed between the upper and lower Limestones; and—

3rd. In the Yellow Sandstone series.

In all these, carbonaceous matter, in the form of coal, has been discovered, in some localities associated with the plants.

The most characteristic plants found throughout are Sigillaria, Stigmaria, Lepidodendron, Calamites, and Ferns.

It is unnecessary to mention any of the localities in which these plants occur in the coal series, as they are abundant in the sandstones, flagstones, and shales of the Connaught coal district, and likewise in the Leinster, Ulster, Tipperary, and Munster coal districts.

Plants occur also in the shales and sandstones, occasionally accompanied by thin beds of coal in the calp series, as at Brookborough, at the base of the Slieve Beagh mountains, county of Fermanagh; at Carrickmacross, where the accompanying coal was worked, though not profitably; at Walterstown and Dowth, county of Meath; and at the Naul, Clontarf, and Loughshinny, in the county of Dublin.

In the yellow sandstone the plants occur in different positions; they are occasionally very abundant, both above and beneath the fish beds, very low down in the series as well as at the base. In many localities these plants are accompanied by *Modiola Macadami*, *Atrypa gregaria*, with many other remains of mollusca and corals; and in several localities ordinary marine fossils belonging to the Carboniferous series lie below them.

In some localities, also, thin beds of coal occur in the immediate vicinity of the plant beds. Such is the case in the yellow sandstone, near Lough Esk, east of the town of Donegal; near Drumquin, county of Tyrone; near Kesh, county of Fermanagh, and north-west of Ballaghaderreen, county of Mayo.

It is unnecessary to mention other localities, as little can be added to the details so ably treated in the paper we have just heard read by Professor Haughton.

AT THE

ANNUAL GENERAL MEETING

HELD ON

WEDNESDAY, FEBRUARY 14th, 1855,

THE PRESIDENT,—JOSEPH BEETE JUKES, ESQ.,

IN THE CHAIR,

The following Report from the Council was read and adopted:

IN presenting their Report of progress during the past year, the Council have to congratulate the Society upon a Session of more than usual activity, in the course of which papers, of which several were of considerable interest, were read before the Society. This increased activity in the Society has reacted in a corresponding manner upon the numbers of new Members, of whom the Society has had an actual gain of *ten* during the year.

The present state of the Society is represented by the following Table, and the names of Members gained and lost during the year are given in the Appendix to this Report:—

Honorary Members,	5
Corresponding Members,	2
Life Members,	43
Annual Members,	86
Associates,	20
Total,	156

During the past year we have had to deplore the removal, by the hand of Providence, of several of our Members, including some of the most honoured and respected names in our list. Your Council believe that they represent your unanimous feeling in expressing their deep sense of the loss we have sustained in the death of Professor Forbes, and of our late Treasurer, Mr. William Edington. In the loss of the former, we share a calamity which is felt wherever the sciences of Natural History and Geology are cultivated; in the

loss of the latter, we suffer a more personal and private grief. Mr. Edington was a Member of our Society from its earliest foundation, and was beloved and respected by every person who had the pleasure of knowing him, and your Council feel that his kind address and conciliating manner will, for a long time to come, be missed in the Geological Society of Dublin.

Your Council have elected provisionally as Treasurer Mr. Gilbert Sanders, and now propose his name to the Society as permanent Treasurer.

During the year, Part 1, Vol. VI., of your Journal has been published, and the second part of the same volume is now nearly ready for publication.

Our increased literary activity has involved increased expenditure in printing, to meet which your Council felt themselves justified in realizing £50 of the stock of the Society, thus reducing the funded property of the Society to £100 stock, which it is proposed to retain permanently to your credit.

The sum thus realized is not more than sufficient to meet the expenses incurred in printing two numbers of the Journal during the year, and your Council are compelled reluctantly to abandon the attempt to publish twice per annum.

The usual audited account for the past year is given in the Appendix, and, in addition, an estimate of receipts and expenditure, from which it appears that, exclusive of the balance of £22 0*s.* 11*d.* to the credit of the Society on January 1, 1855, a sum of £27 5*s.* will be available for the printing of the next number of the Journal. This sum will print a Part of about 100 pages, within which limit your Council propose to confine the next number of the Journal; and, to effect this object, they invite the co-operation of Members contributing papers, in order that the substance of each paper may be condensed within the narrowest limits, consistent with clearness of statement. Your Council hope that the coming year will witness increased zeal, and that the continued exertions of the Members will enable them still further to extend the sphere of their utility.

APPENDIX TO ANNUAL REPORT.

No. I.

MEMBERS ADDED.

Honorary Corresponding Members.

Thomas Oldham, Esq., F. R. S.
Arthur A. Jacob, Esq., C. E.

Honorary Members.

Rev. Adam Sedgwick, F. R. S.

Life Members.

Edward Barnes, Esq.
John P. Clemes, Esq.
Frederick J. Foote, Esq.
Warington W. Smyth, Esq.

Annual Members.

Samuel Ashton, Esq.
John T. Banks, M. D.
Henry M. Barton, Esq.
Charles H. Domville, Esq. (rejoined.)
Henry English, Esq., C. E.
Rev. George Longfield, F. T. C. D.
Alexander M'Arthur, Esq.

Associates.

David C. Cochrane, Esq.
Edward Crofton, Esq.
John J. Maguire, Esq.
William Henry Noble, Esq.
Wilton Oldham, Esq.
Robert H. Scott, Esq.

LOST FROM DEATH AND OTHER CAUSES.

Life Members.

Professor Edward Forbes, F. R. S.
Robert Forster, Esq.
The Earl of Leitrim.

Annual Members.

Rev. Harvey Ashworth.
Richard Barney, Esq.
William Edington, Esq.
Rev. Charles Graves, D. D.
John Radcliffe, Esq.
Richard W. Townsend, Esq.

Associate.

John Cogan, Esq.

Total added, ...	20
Total lost, ...	10
Gained, . .	10

No. II.

DONATIONS TO THE LIBRARY.

1854.

Feb. 16.—Reports of the British Association for the Advancement of Science, for the years 1851 and 1852. Presented by the Association.

Mar. 8.—Quarterly Journal of the Geological Society of London, No. 37. Presented by the Society.

Mar. 17.—Proceedings of the Literary and Philosophical Society of Liverpool, No. 7. Presented by the Society.

April 12.—Transactions of the Kilkenny Archæological Society, for the year 1852. Presented by the Society.

April 25.—Journal of the Royal Geographical Society, Vol. XXIII.; with a General Index to the Second Ten Volumes of the Journal of the Royal Geographical Society. Presented by the Society.

May 10.—Proceedings of the Royal Society, Vol. VII., Nos. 1 and 2. Presented by the Society.

June 7.—Transactions of the Dublin University Philosophical Society, Vols. I. to VI. (1843–54). Presented by the Society.

July 3.—Siluria. The History of the oldest known Rocks containing Organic Remains, with a brief Sketch of the Distribution of Gold over the Earth, by Sir Roderick Impey Murchison, G. C. St. S., &c. Presented by the Author.

July 15.—Address delivered at the Anniversary Meeting of the Geological Society of London, on the 17th of February, 1854, by Edward Forbes, Esq., President of the Society. Presented by the Author.

July 19.—On Coal; by Professor Harkness. Presented by the Author.

Sept. 13.—Reports of the Proceedings of the Geological and Polytechnic Society of the West Riding of Yorkshire, 1850, 1851; with a Guide to the Museum of the Leeds Philosophical and Literary Society. Presented by the respective Societies.

Sept. 13.—Calcolo Decidozzinale del Barone Silvio Ferrari, Cav. de' SS. M. E. L., Fregiato dell' Uniforme Militare di Quest' Ordine. Consigliere d' Appello. Dedicato Alla Nazione Inglese. Presented by the Author.

Oct. 4.—Annales des Sciences Physiques et Naturelles, d'Agriculture et d'Industrie, publiées par la Société Impériale d'Agriculture, &c., de Lyon. Deuxième Série, Tome IV. V. (1852–53). Presented by the Society.

Oct. 4.—Mémoires de l'Académie Imperiale des Sciences, Belles-Lettres et Arts de Lyon. Classe des Sciences, Tom. II. Classe des Lettres, Tom. II. (1852–3). Presented by the Academy.

Oct. 7.—Notes upon the Geology of the Rajmahal Hills; being the Result of Examinations made during the cold season of 1852–53; by Thomas Oldham, Esq., F. R. S. Presented by the Author.

Nov. 8.—Smithsonian Contributions to Knowledge:—The Ancient Fauna of Nebraska, by Joseph Leidy, M. D. Notes on New Species and Localities of Microscopical Organisms, by J. W. Bailey, M. D. Registry of Periodical Phenomena. Seventh Annual Report of the Board of Regents of the Smithsonian Institution. List of Foreign Institutions in Correspondence with the Smithsonian Institution. Natural History of the Red River of Louisiana. Presented by the Smithsonian Institution.

Nov. 8.—Boston Journal of Natural History, Vols. I. to V., and Vol. VI., No. 3, (1837–53). Proceedings of the Boston Society of Natural History, Vols. I. to III., and Nos. 15 to 24 (1844–54). Presented by the Society.

Nov. 16.—Report of the Twenty-third Meeting of the British Association for the Advancement of Science; held at Hull, in September, 1853. Presented by the Association.

Dec. 13.—Transactions of the Royal Scottish Society of Arts, Vol. IV., Part 2. Presented by the Society.

Dec. 13.—Proceedings and Transactions of the Kilkenny and South-East of Ireland Archæological Society, for the year 1854, Vol. III., Part 1. Presented by the Society.

Dec. 14.—Ireland's Recovery:—An Essay, by John Locke, A. B. Presented by the Author.

Dec. 29.—Proceedings of the Literary and Philosophical Society of Liverpool, 1853–54, No. 8. Presented by the Society.

1855.

Jan. 2.—Address delivered at the Anniversary Meeting of the Geological Society of London, on the 17th of February, 1854, by Edward Forbes, Esq., President of the Society. Presented by the Society.

Jan. 2.—Quarterly Journal of the Geological Society of London, No. 40. Presented by the Society.

Feb. 7.—Quarterly Journal of the Geological Society of London, Nos. 38 and 39. Presented by the Society.

Feb. 14.—Journal of the Society of Arts, Nos. 64 to 116. Presented by the Society.

Feb. 14.—The Musical Times, Nos. 118 to 138. Presented by the Editor.

Feb. 14.—The Athenæum, 1854. Presented by the Editor.

Feb. 14.—The Literary Gazette, 1854. Presented by the Editor.

Feb. 14.—A General Map of Ireland to accompany the Report of the Railway Commissioners, showing the Principal Physical Features and Geological Structure of the Country. Revised and improved in 1853. By Richard Griffith, LL. D. Presented by the Compiler.

No. III.

LIFE COMPOSITIONS.

	£	s.	d.
Edward Forbes, Esq., F. R. S., ...	5	0	0
Frederick J. Foote, Esq., ...	5	0	0
John P. Clemes, Esq., ...	5	0	0
Warington W. Smyth, Esq., ...	5	0	0
	£20	0	0

ADMISSION FEES.

	£	s.	d.
Richard W. Townsend, Esq., ...	1	0	0
Henry Kingsmill, Jun., Esq., ...	1	0	0
Henry Geoghegan, Jun., Esq., ...	1	0	0
George MacCartney, Esq., ...	1	0	0
George W. Hemans, Esq., ...	1	0	0
Samuel Ashton, Esq., ...	1	0	0
Rev. George Longfield, F. T. C. D., ...	1	0	0
John Locke, Esq., ...	1	0	0
Henry English, Esq., ...	1	0	0
	£9	0	0

ANNUAL SUBSCRIPTIONS.

	£	s.	d.
R. W. Townsend, Esq., . . .	1	0	0
Halliday Bruce, Esq., . . .	1	0	0
H. Kingsmill, Jun., Esq., .	1	0	0
H. Geoghegan, Jun., Esq., .	1	0	0
John Kennedy, Esq , . . .	1	10	0
W. H. Curran, Esq., ...	1	0	0
James F. Duncan, M.D., .	1	0	0
George M'Dowell, F. T. C. D.,	1	0	0
G. W. Hemans, Esq., . . .	1	0	0
Richard Griffith, LL.D., . .	1	0	0
Gilbert Sanders, Esq., . . .	1	0	0
R. W. Smith, M. D., ...	1	0	0
Evelyn J. Shirley, Esq., . .	1	0	0
William Dawson, Esq., . . .	1	0	0
Edward Wright, LL.D., .	1	0	0
Robert Mallet, Esq., ...	1	0	0
The Rev. the Provost, . .	1	0	0
Carried forward,	£17	10	0

	£	s.	d.
Brought forward,	17	10	0
C. W. Hamilton, Esq., . .	1	0	0
Dr. J. I. Whitty, LL.D., .	1	0	0
James Apjohn, M. D., . .	1	0	0
John Patten, Esq., . . .	1	0	0
Thomas Maguire, Esq., . .	1	0	0
George MacCartney, Esq., .	1	0	0
John Purser, Esq., . . .	1	0	0
Thomas Hutton, Esq., . .	1	0	0
John Mollan, M. D., . . .	1	0	0
Francis M. Jennings, Esq. (1853–54), ...	2	0	0
John England, Esq., . . .	1	0	0
Joseph Welland, Esq., . .	1	0	0
William Scott, Esq., . .	1	0	0
Matthew D'Arcy, Esq., . .	1	0	0
Rev. Harvey Ashworth, .	1	0	0
Carried forward,	£33	10	0

	£	s.	d.
Brought forward,	33	10	0
Rev. H. Lloyd, D. D., . .	1	0	0
John Nicholson, Esq., . .	1	0	0
Right Hon. John Wynne, (1853–54), ...	2	0	0
Charles P. Croker, M. D., .	1	0	0
L. White, Esq. (1853–54),	2	0	0
George J. Allman, M. D., .	1	0	0
Arthur M'Guire Giles, Esq.,	1	0	0
The Earl of Bective, . . .	1	0	0
Samuel Downing, Esq., . .	1	0	0
The Earl of Leitrim, . . .	1	0	0
Lieut.-Col. Portlock, R. E., .	1	0	0
Robert Callwell, Esq., . .	1	0	0
The Archbishop of Dublin, .	1	0	0
Richard Wolseley, Esq., . .	1	0	0
William Clarke, Esq., . .	1	0	0
F. J. Sidney, LL. D., . .	1	0	0
George Yeates, Esq., . .	1	0	0
The Earl Fitzwilliam, . .	1	0	0
John MacDonnell, M. D., .	1	0	0
Robert Ball, LL. D., . . .	1	0	0
Samuel Gordon, M. D., . .	1	0	0
Patrick Byrne, Esq., . . .	1	0	0
Samuel Ashton, Esq., . .	1	0	0
Carried forward,	£58	10	0

	£	s.	d.
Brought forward,	58	10	0
Rev. C. W. Wall, D. D., .	1	0	0
R. Hitchcock, Esq., . . .	1	0	0
G. H. Kinahan, Esq., . .	1	0	0
William T. Mulvany, Esq. (1852–53–54), ...	3	0	0
Henry Head, M. D., . . .	1	0	0
Rev. Joseph A. Galbraith, F. T. C. D., ...	1	0	0
Rev. J. H. Jellett, F.T.C.D.,	1	0	0
M. M. O'Grady, M. D., . .	1	0	0
R. Barney, Esq. (1853–54),	2	0	0
Rev. Charles Graves, D. D.,	1	0	0

Associate Members.

	£	s.	d.
Arthur Jacob, Esq., . . .	0	5	0
Thomas M'Comas, Esq., .	0	5	0
Charles Newell, Esq., . .	0	5	0
John Haughton, Esq., . .	0	5	0
Robert C. Smith, Esq., . .	0	5	0
Charles P. Cotton, Esq., (1852–53–54), ...	0	15	0
	£73	10	0

No. IV.

ABSTRACT OF THE TREASURER'S ACCOUNT FOR THE YEAR ENDING 31st DECEMBER, 1854.

Dr.

1854.	£	s.	d.
To Interest on Government Stock,	2	8	11
— Received for Sale of Journals,	6	6	0
— " Life Subscriptions,	20	0	0
— " Admission Fees,	9	0	0
— " Annual Subscriptions,	73	10	0
	111	4	11
— " Per Sale of £50 Government Stock,	46	5	4
	£157	10	3

Cr.

1854.				£	s.	d.
By Balance from last Year,				31	9	5
Feb. 15.—By Salary to Assistant Secretary, (Draft 5130),				10	0	0
— Sundries, per Assistant Secretary's book,	9	18	10			
— Sundries, Dr. Whitty for Engravings,	3	10	0			
(per Draft 5131),				13	8	10
Mar. 15.—By Sundries, per Assistant Secretary's book,	7	2	1			
By Sundries, per Attendant,	1	10	0			
June 7.— (per Draft 5132),				8	12	1
Aug. 10.—By Salary to Assistant Secretary, per late Treasurer,				10	0	0
Oct. 1.—By Collector's Commission, per Treasurer,				3	19	6
By Sundries, per Assistant Secretary's book,	8	6	6			
By Sundries, per John Tallon, Stationery,	0	14	0			
Dec. 20.— (per Draft 5133),				9	0	6
Dec. 20.—By Mr. Oldham, Engraving (Draft 5134),				11	12	6
Dec. 30.—By Mr. Gill, Printing (Draft 5136),				35	14	0
By Collector's Commission,	1	6	0			
Account Book,	0	6	6			
Dec. 30.— (per Draft 5135),				1	12	6
By Balance forward,				22	0	11
				£157	10	3

GILBERT SANDERS, *Treasurer, pro tem.*

We have examined the above Account, and compared Vouchers, and find a balance to the credit of the Society of £22 0*s.* 11*d.*

Feb. 7, 1855.

JOSEPH A. GALBRAITH,
ROBERT CALLWELL.

No. V.

ESTIMATE FOR THE YEAR 1855.

	£	s.	d.		£	s.	d.
Annual Subscriptions, . .	80	0	0	Assistant Secretary's Salary,	20	0	0
Life " . .				Attendant, ...	1	10	0
Admissions, ...	5	0	0	Incidentals, ...	30	0	0
Sale of Journals, ...	1	10	0	Collector's Poundage, . .	4	5	0
Interest of Stock, . . .	3	0	0	Stationery and Miscellaneous Printing, ...	6	10	0
	£89	10	0	Printing, ...	27	5	0
					£89	10	0

The following Officers for the ensuing year were then declared duly elected, and the Society adjourned to receive the President's Annual Address:—

President:

LORD TALBOT DE MALAHIDE.

Vice-Presidents:

JOSEPH BEETE JUKES, ESQ., M. R. I. A.
REV. HUMPHREY LLOYD, D. D., S. F. T. C. D.
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ANNUAL ADDRESS

DELIVERED BEFORE THE

GEOLOGICAL SOCIETY OF DUBLIN,

FEBRUARY 14, 1855,

BY

JOSEPH BEETE JUKES, M.A., F.R.S.

PRESIDENT OF THE SOCIETY.

I REGRET, Gentlemen, that on the present occasion I am compelled to commence with an apology. My time has been so entirely absorbed during the past twelve months by the duties of the Geological Survey, to which latterly have been added those of the lecture-room, that I have not been able to cast even a hasty glance over the general progress of Geology, and am, therefore, not in a condition for giving you any report upon it. Neither can I describe to you even what particular advances have been made in any branch of our science except among ourselves. In short, the matter which I am about to lay before you has been chiefly written in the hour or two before daylight of these late winter mornings (the only time I could devote to the purpose), and is by no means such as I had hoped and expected to have had to produce. "The longer one lives, the busier one gets," would be an adage that would suit my experience of the last four or five years.

WILLIAM EDINGTON, ESQ.

The first portion of my task, Gentlemen, is a very melancholy one. We have to lament the death of our late Treasurer, Mr. Edington, a gentleman whose kindly disposition and pleasant manners endeared him to us all, while his indefatigable attention to our interests, both financial and general, made him of the greatest value

to our Society. I am enabled by the kindness of a friend to give the following brief sketch of his life:—The late William Edington, Esq., was born at East Wemyss, Fifeshire, on the 27th of January, 1783, and was the son of James Edington, Esq., of that place. He came to Ireland previously to the rebellion of 1798, under the auspices of his uncle, the late John Armit, Esq., at that time the head of the old-established firm of Borough, Armit, and Co., Army Agents. His zeal and assiduity in business soon made him a member of the firm, where his integrity, systematic habits, and attentive management of the financial duties of the house, contributed to maintain its established reputation during a period of fifty years. He was one of the partners at the time of his death, which took place after an illness of four days, on the 13th of August, 1854.

PROFESSOR EDWARD FORBES.

The next name I have to mention is one of which I hardly know how to speak. The bitter pang of personal regret for the loss of a dearly loved and highly valued friend mingles with and renders more deep and acute our sorrow for the extinction of one of the great lights of our science. The news of his death fell upon my heart, and that of others here present, as a great public and private calamity—a sad and dreary recollection never to be banished from our minds, but to mingle with all our social feelings and with all our mental actions during the remainder of our lives. Beyond the wide circle of his personal friends, however, the loss of Professor Edward Forbes is one which we share with the whole world of science. It is one, the magnitude of which is daily more and more felt and appreciated, for we look in vain for any one to supply his place, either in the field of natural science, or in the social life of scientific men. His heart and his intellect were alike large and catholic in their instincts and capacities. He seemed not to perceive, or, perceiving, not to regard, the failings and imperfections of men, but to look at their capabilities, and seek for and call forth what powers and good qualities they possessed. It mattered not to him of what party, of what sect, of what rank, or of what nation, a man was, if he had in him any love for natural science, any desire or any power of aiding its extension, he might be sure of hearty appreciation and effectual aid and encouragement from Edward Forbes. It was this spirit of fellowship, this instinct of union and of solidarity (to use a newly-

coined word) among all scientific men, which seemed the natural impulse of Forbes' mind, the abstraction of which may be a yet greater loss than even that of his own power of scientific investigation and discovery. I do not mean to say that he shunned controversy or discussion on scientific or other points; still less that he would be unduly tolerant of pretension or of error; but that he, in such cases, looked solely to the scientific bearings and relations of the subject, and would naturally and easily waive off and disregard all the personal feelings, the individual anger, or envy, or jealousy, or contempt, or malice, which are apt to creep into men's breasts when they are in any way led into contention. He was one of those who, while he would not hesitate to oppose openly and frankly the opinions of his best friends when they conflicted with his own, never in so doing lost a friend,—never, I believe, made an enemy of a stranger. Even in cases where much ignorance or much error was displayed, if he thought it exhibited in an earnest and honest endeavour after truth, he would not only treat the shortcomings leniently in public, but give up much of his valuable time in private to assisting and instructing the inquirer. I insist all the more strongly on this side of Edward Forbes' character, because I think it is incumbent upon all his friends to do their best to cherish and extend this spirit, which he by no means monopolized, but for which he was remarkably distinguished. The rancour and jealousy and bitterness which for so long had been the distinguishing reproach of scientific and literary men, have of late years greatly diminished. It is high time that they should altogether cease to give cause for scandal to the rest of the world, and that those who claim to breathe a higher and calmer atmosphere, to have their powers and faculties busied with purer and loftier subjects than the generality of men have, should show the effect of this nobler employment and this higher station, by exhibiting their minds and tempers free from the little personal strifes and enmities, the jealousy and uncharitableness, of common life, and should be characterized by that generosity and largeness of heart which always puts the best instead of the worst construction on the actions of others—always accepts and appreciates the good, and passes by and ignores the faulty and the bad. Men of science should look upon their common pursuit as giving them a claim on each other's consideration, greater than what any difference of creed, or party, or country, or wealth, or station, can injure

or efface. As Nature's priests, and as God's nobility, they should train themselves to act with the temper, the calmness, and the dignity of their high calling, and, doing that, to remember moreover, to "stand by their order."*

Although Professor Edward Forbes possessed all those natural powers of minute and accurate perception and discrimination, without which no man can become a real observer in natural history, he was the opposite of a mere species maker. His mind could not rest satisfied with the mere knowledge of the minute distinctions and differences between objects, but was ever seeking to arrive at the laws of union and connexion which group species into natural assemblages, and show the relations of those assemblages to each other. He never remained satisfied with the knowledge of a barren fact where it was possible so to connect it with others as to make it tell a story. His ultimate aim and object was the philosophy of natural history in its widest and loftiest sense. It is greatly to be deplored that he did not live to gather together, and condense, and arrange, his views on this subject.† We must, however, rest content now with the scattered hints and ideas and suggestions so liberally thrown forth in his many lectures and papers and memoirs, knowing that the impulses he has imparted to men's minds, and the directions he has given to their thoughts, will be fruitful in results for many long years to come.

It would lead me into too great lengths if I were to attempt here to give an account of his general labours for the extension of our

* I have not allowed myself to be swayed by the fear of appearing presumptuous in uttering the above words to my scientific brethren. We shall all unite in one opinion as to their abstract propriety. What is wanted is their more frequent and general expression and inculcation. It is sometimes a subject of complaint that science is not sufficiently regarded, and scientific men have not their proper place in the British Empire. Let them once act heartily and cordially together, and they may do what they will, provided it is what they ought.

† Perhaps I may be pardoned for mentioning here that only last year Forbes had done me the honour of wishing to associate me with himself in the production of an elementary Treatise on Geology. We had partly arranged the plan of it at the meeting of the British Association in Liverpool last September. I feel it a deep personal loss to myself to have missed the opportunity of having my name so honourably associated with one so widely and so lastingly known as his; but a far greater, because more general, loss is the want of that condensed account of the principles, the laws, and the results of palæontological science which he would there have given. I hardly see at present any chance of this loss being in any adequate way compensated for.

science; but it comes directly within the business of this Address to describe those that had distinguished the past year. Of these the most remarkable is his Address to the Geological Society of London, which he concluded by shadowing out a new proposition as to the classification and nomenclature of our science, and a new idea in its theoretical philosophy. His proposition rests upon ascertainable facts,—namely, what is the relative value of the differences between the organic remains of our three great divisions of stratified rocks, —Palæozoic, Mesozoic, and Kainozoic. He asserts that the difference between the Mesozoic and Kainozoic (secondary and tertiary) is not so great as that which exists between these two taken together, and the Palæozoic. He would, therefore, propose to amalgamate the two former under the common name of "Neozoic," and to divide the whole series of stratified rocks into two great classes, Palæozoic and Neozoic. This is a proposal which must be left to the future labours of palæontologists to decide upon. It is a problem that will work itself out either negatively or affirmatively; but, coming as it does from one whose knowledge was so various, so extensive, and so accurate, it has a strong *à priori* claim on our consideration, if not on our belief.

The theoretical idea, which is founded upon this proposed classification, is one that, if the truth of the proposition be established, may be taken up with it, or not, subsequently, and it is one which will probably recommend itself in different degrees to different men's minds. It is a *quasi* metaphysical notion of the manifestation of a relation among organic beings in geological time, which relation is called polarity.

By polarity, used in this sense, is meant the manifestation of a force of development in two opposite directions, which two directions may be represented by the opposite poles of a sphere.*

He looked at the Permian and Triassic formations as the point of contact of the two spheres or circles of Palæozoic and Neozoic life, and, remarking the comparative barrenness of these two formations in generic types, pointed out that the development of those generic types increased in each direction from this point of contact, the maximum of Palæozoic types being found in the earlier, of Neozoic in the later epochs. He says, in his lecture on this subject at the

* See the Report of a Lecture delivered at the Royal Institution, an abstract of which is to be found in Jameson's Edinburgh Philosophical Journal (October, 1854).

Royal Institution, "that, during the Palæozoic period, the sum of generic types and concentration of characteristic forms is to be observed in Silurian and Devonian formations; during the Neozoic period it is during the Cretaceous, Tertiary, and present (itself part of the Tertiary) epochs that we find the maximum development of peculiar generic types (or ideas). On the other hand, during the closing epochs of the Palæozoic, and the commencing epoch of the Neozoic period, there was a poverty in the production of generic ideas, the species of the epochs in question, with few exceptions, being members of genera that form constituents in the assemblage accumulated during the epochs of maximum of generic types or ideas.

"Before the Silurian, and after the *commencement* of the present, no special creations of generic types have as yet been shown to be manifested. In the system of life composed of all known creatures, living or extinct, as yet described, so far as our knowledge extends —and there is a consistency in its co-ordination that suggests the probability of our being acquainted with its extremes,—the creation of the Fauna and Flora of the oldest Palæozoic epoch would seem to be the primordial, and the appearance of man the closing biological events."

He then proceeds to point out the existence of this relation of "polarity" in particular groups, showing that different groups that are parallel within their sub-kingdoms and classes take the place of each other, and play a corresponding part in the two great epochs; but "this replacement does not depend on the substitution of a group of higher organization during the latter epoch, for one of lower during the former." He gives the following as a few leading examples of what he means:—

Neozoic.	Palæozoic.
Cycloid and Ctenoid Fish.	Ganoid and Placoid Fish.
Malacostracous Crustacea.	Entomostracous Crustacea.
Dibranchiate Cephalopoda.	Tetrabranchiate Cephalopoda.
Lamellibranchiate Acephala.	Palliobranchiate Acephala.
Echinoidea.	Crinoidea.
Six starred corals.	Four starred corals.

Each of these respective groups increasing in number of generic types as we go backwards into the Palæozoic epoch towards the Silurian period, and forwards into the Neozoic epoch towards the Tertiary period, from the point of contact of the two epochs. He put

forward this idea avowedly as a mere hint for the future, as a seedling which should either die away, or flourish and bear fruit hereafter, according to the vitality and strength of truth that was in it.

SIR R. I. MURCHISON'S SILURIA.

One publication of last year I found time to read, and must not here altogether omit mention of it, and that is the "Siluria" of Sir Roderick Murchison. In this volume Sir Roderick has given a condensed account of his own labours, and those of other geologists, on the Palæozoic rocks generally, and the Silurian in particular. This book must henceforth become a *vade mecum* to all geologists, as the illustrious author intended it. It is most admirably illustrated, not only by figures of most of the fossil forms published in the original great work on the "Silurian System," but of others since discovered in Britain and elsewhere. To these are added many pictorial illustrations and reduced sections, together with some maps, one of which is a coloured copy on a reduced scale of the original map of Siluria, with the addition of the work of the Geological Survey in North and South Wales.

To enter into a full description of this most useful and excellent volume would lead me to too great lengths, while the discussion of the numerous questions that would arise in the course of it would occupy the whole space of this Address.

PAPERS LAID BEFORE THE SOCIETY.

In commenting upon our own labours during the past year I would first of all congratulate the Society upon the increasing value and importance of the papers communicated to us. It should be our aim to place the publications of the Geological Society of Dublin among the recognised authorities of the science; an object we need not despair of attaining if we strive earnestly for it, and look upon our own local and smaller body merely as an organ through which to address the general geological public.

The first paper that comes before me is one by my friend and colleague, Mr. Andrew Wyley, of the Geological Survey,* containing an abstract of some of the results obtained during the Survey of

* I regret to say that Mr. Wyley is now no longer my colleague, he having accepted an appointment at the Cape of Good Hope, to examine and report on the mineralogical resources of that colony.

the county of Kilkenny. It is entitled: "On the Character and Mode of Occurrence of the Dolomitic Rocks of Kilkenny," and describes two kinds of magnesian limestone occurring in that district, the one apparently deposited as a magnesian limestone, interstratified with the other beds of the Carboniferous limestone; the other, a true dolomite, almost certainly the result of a subsequent alteration of the rocks, and putting on many of the appearances familiar to us in the dykes, veins, and intrusive masses of igneous rocks. He supposes the magnesia of these to have been sublimed from below, and points to the possibility of its having aided in the conversion of some granitic rocks into greenstones, and to the probable period of the alteration being that of the deposition of the Magnesian limestone of the Permian formation. The paper, being itself an abstract, will not admit of any further condensation; but I can confidently commend it to the attention of all geologists.

The next paper is one by Professor Haughton, on "The Iron Ores of Caernarvonshire," giving a chemical analysis of some of these ores, and stating the difficulty met with in ascertaining whether they occurred in beds or in lodes, but preferring to consider them as beds. In this preference Professor Haughton agrees with Professor Sedgwick and the officers of the Geological Survey, and all others, as far as I am aware, who have mentioned their occurrence.

We have then a very long and elaborate paper by Mr. John Kelly, "On the Drift of the District above Rathfarnham, in the county of Dublin."

This is a subject which I have not been able to devote much attention to myself, though it is a most interesting one, and one for the study of which Ireland presents some peculiar advantages.

A former distinguished member, and once President of this Society, Dr. Scouler, was the first to point this out in his short, clear, and excellent paper, published in the first volume of our Journal.

I may be permitted, perhaps, here, Gentlemen, to regret that one who, by his great powers and attainments, is in every way so fitted to aid us in the prosecution of this and all other branches of our science, should not, of late years, have afforded us the advantage of his cooperation.

Mr. Kelly's paper is a very valuable one, as giving us a connected and detailed account of many observed facts respecting the drift. His general division of the gravel into "corn gravel" and "road

gravel,"—the first and lowest consisting of a blue clay, containing limestone pebbles, usually small and well rounded; the last, generally the uppermost, of brown sand and pebbles, with little or no clay,—interested me as agreeing with what I had myself observed not only in the neighbourhood of Dublin, but frequently in the south of Ireland, as far even as Bantry Bay. Round the head of that Bay are many rounded hills, rising to more than 200 feet in height, forming promontories or islands, or mounds in valleys, which are altogether composed of drift, consisting of blue clay, with limestone blocks and pebbles, capped by brown sand, with pebbles of slate and sandstone. These seemed to me to be patches of a much more widely extended drift formation, which had been principally removed by subsequent denudation from the district. Some of the patches mentioned by Mr. Kelly are probably not entirely due to partial deposition, but that partial deposition has been aided by subsequent unequal denudation, which will also account for the bare patches occurring in the middle of drift districts.

Mr. Kelly sums up his facts as follows:—"I have thus shown that in this district drifted or transported gravel, derived from Carboniferous rocks, is found resting on Granite at every height, varying from 100 to 1300 feet above the level of the sea: that it occurs in detached patches, at the height of 1000 feet and upwards, in some places, lying on the sides of the hills; that there is one patch so low as 330 feet, which has not any of this gravel, although surrounded by it on every side; that extensive areas are covered with it, on the slopes of the mountains, at heights varying from 300 to 1000 feet; and that extensive areas, on the same range, on similar slopes, have no gravel higher than between 300 and 400 feet."

While thanking Mr. Kelly for his facts, however, I cannot agree with him in his proposed explanation of them by means of great earthquake waves sweeping over the land, and lifting large ice-floes, formed in lakes, and laden with frozen-in gravel, on to the flanks of the hills.

The fact of limestone gravel being found on the hills, at a height of 800 or 1000 feet above the limestone plain, from which we must believe the fragments to have been derived, is not, perhaps, easy to explain, nor will I now attempt it. The hypothesis, however, of the general depression of all Ireland some 1300 or 1400 feet beneath the waters of the glacial sea, and its subsequent gradual elevation, either

by a continuous motion or by small starts, and in either case unequally perhaps in different places, and at different times, would appear to me adequate to the explanation of all the phenomena of the drift when carefully applied to it, and is absolutely necessary to that of the occurrence of marine shells, as noticed by Mr. Kelly, at a height of 600 feet above the present level of the sea at the north end of the little townland of Corrageen, to the east of Glenismaule.

Neither can I accept as satisfactory to myself Mr. Kelly's explanation of the formation of escars by means of ice-floes. These very remarkable ridges of gravel always appeared to me to have been deposited in the eddy or slack water between two currents, running in more or less different directions, in a shallow sea, just when the ground had risen up to the proper distance beneath the sea-level for their production. They are analogous to the banks of sand and pebbles, often running parallel to the shore of a low coast, at a distance of a few hundred yards, or three or four miles from it. Possibly the banks running down the shores of Dublin, Wicklow, and Wexford, may be escars now forming, or something similar to them, or they may have a central nucleus of escar, concealed and covered up by loose sand, which, as they emerged from the sea on elevation, would be more or less completely eroded and swept away.

The irregular and contorted lamination and stratification observed by Mr. Kelly may, in some cases, be due to local shrinking and shifting of the mass, but is not necessarily so, as the same or still greater twistings of layers may be observed in recent sand-banks, and in many sandstones and conglomerates, and is the result of irregular deposition only. I have seen the most curiously waved and undulating layers of sand in the New Red of England, and similar facts may be seen in the Old Red of the south of Ireland.

Next to Mr. Kelly's paper comes one by Professor Galbraith, "On the different Analyses of Killinite;" and the same gentleman subsequently favoured us with his "Analyses of the Felspars of the Dublin and Wicklow Granites." As these are questions on which I have no opinion of my own to offer (never having considered myself competent to meddle with chemical analysis, as I knew the only result would be the certain breaking of the bottles, and the probable burning of my fingers), I shall content myself with the simple expression of my satisfaction, that any of our members should give themselves the trouble to undertake these valuable investigations.

Professor Haughton has given us, in the second of his "Geological and Statistical Notes on Irish Mines," a paper on the "Luganure Lead Mines." This is likewise a subject of which my own knowledge is limited, and one which I can never get time to investigate. Although it is one not altogether devoid of interest to our science;—that interest lies within a comparatively narrow scope, and has never yet been fully or adequately drawn forth. As a contribution to the difficult subject of mineral veins, Professor Haughton's paper is valuable, as it is full of details of facts, both mining and mineralogical, observed, doubtless, with accuracy, and graphically described. It will, moreover, be useful as a record and register of data both to the miner and to the mineralogist.

I pass over a small paper of my own, "On an Outlier of Carboniferous Limestone at Taghmon, in the county of Wexford," showing the great analogy between that and the patch at Hafody Calch, near Corwen, in North Wales, and the proof of great denudation given by both; and also a note by my friend and colleague, Mr. Willson, on a former paper of Mr. Triphook's; and come to a paper by Mr. Jacob, one of our younger members, containing an "Account of a Reconnaisance of the Nurbudda Valley in Central India."* This paper gives a brief sketch of some interesting features in the geology of that district. Such communications are valuable not only as adding to our general stores of information, but as reminding us that there are other countries beside our own with whose geological history we ought to be acquainted.

Mr. John Lloyd's paper, entitled a "Notice of a Seam of Fossiliferous Limestone in the Millstone Grits of the county of Clare," makes us acquainted with a new fact in the geology of the neighbourhood of Kilkee, and with the name of a new observer in our science, from whose labours we may hope for still further results.

Next comes Dr. Whitty's paper: "Notice of the Anthracite found in the Silurian Rocks in the county of Cavan."

The occurrence of this anthracite is interesting in several ways, first, as pointing to the probable existence of vegetable life at that early period of the earth's history, although no distinct vegetable forms have yet been discovered; and secondly, as linking more closely

* I believe I am correct in saying that this district is about to receive a more detailed examination at the hands of our late fellow-members, Messrs. Medlicott and Kennedy, under the direction of my distinguished predecessor, Professor Oldham.

the Silurian rocks of the north-east of Ireland with those of the opposite coast of Scotland, where a similar band or bands had been long ago pointed out by Professor Harkness of Cork. Though of very considerable geological interest, I fear that this Carbonaceous bed does not promise any valuable economic results to its possessors.

We come now to an excellent and very interesting paper by our old friend, Dr. Griffith, on "The Copper Beds of the South Coast of the county of Cork." I need not say with how much pleasure we welcome him as once more an original contributor to our Journal. His paper commences with a rapid sketch of the physical geography of the mountainous country between Dingle Bay and the mouth of the Blackwater, and then proceeds to describe the rocks of which the country is composed, and the relative and actual positions which they occupy. These descriptions are, as we should expect, perfectly accurate; and I may take this opportunity of stating that myself and the other officers of the Geological Survey were delighted at the correctness of Dr. Griffith's map of the south-west of the county of Cork, in our recent examination of that district.

Dr. Griffith then discusses the classification of these rocks, especially as to the settling of the boundary line between the Devonian and Carboniferous formations, and alludes to a difference of opinion between him and myself as to the exact position of this boundary. As I fear that I may possibly be on the brink of a controversy on this question unless I state clearly and fully my own views with regard to it, and as it would be a controversy which I by no means intended ever to enter into, and shall certainly leave to time and further research to conduct for me, I will, with your permission, state my own position in this matter.

In March, 1852, I read a paper to this Society on the Geology of the county of Waterford, in which I proposed to classify Dr. Griffith's Carboniferous Slate and Yellow Sandstone as upper Devonian rocks, depending for that classification on physical structure alone. It was in the discussion on that paper that I learned for the first time that this view was contrary to the *confirmed* opinion of Dr. Griffith, and that he still looked not only on the Carboniferous Slate, but also on the Yellow Sandstone, as belonging to the Carboniferous formation.

From what I had then seen of these rocks, namely, their extension from Waterford to Cork, the view I then took of the gradual

passage, laterally, of the Yellow Sandstone into the Carboniferous Slate, was perfectly well founded. The Yellow Sandstone seemed to be gradually dying out towards the west, and the Carboniferous Slate to be increasing at its expense. At Monkstown, near Cork, where there is the best and most continuous section from the middle of the red slates to the base of the Carboniferous Limestone, there is not a trace of *yellow sandstone*, lithologically speaking, the rocks graduating upwards from deep red and purple slate, through purple and green slates, into blue and bluish black or grey slates, with occasional grit beds throughout, of the same colour as the slates; and on the top of the dark gray slates come beds of solid Carboniferous Limestone. I have since learned, however, that, still further west, beds, having the lithological character of the yellow sandstone, set in again, and that it is possible, in several places to the westward, to make a physical tripartite division into red slates and grey slates, and an intermediate band of yellow (or variegated) sandstone and slate between them.

In all cases, however, both in Waterford and Cork, it is difficult, indeed almost impossible, to draw, by any physical characters, whether of structure, or texture, or colour, a very precise and definite boundary between the Old Red and the Yellow Sandstone. These beds are all blended together both vertically and laterally, red slates being in some cases continued from the heart of the Old Red up almost to the very base of the Carboniferous Limestone. Physically, therefore, there is only one good base line for the bottom of the Carboniferous rocks, and that is *the base of the actual limestone itself;* and there are not wanting other physical circumstances, in addition to mere lithological character, to induce us to draw a line of separation of some sort between the limestone and all the beds below it.

I am now speaking entirely independently of the fossils, but I had understood generally, at the time I read the paper aforesaid, that professed palæontologists had spoken of the fossils occurring in the beds below the limestone as having a Devonian aspect, and I understood also, on the authority of Sir Henry de la Beche,* that remains of plants occurred in the upper part of the undoubted Old Red Sandstone of South Wales. I was aware also that opinions had

* Memoirs of the Geological Survey, vol. i. p. 58, *et seq.*

changed as to which fossils were characteristically Devonian and which Carboniferous, since 1842, when Dr. Griffith published his "Notice respecting the Fossils of the Mountain Limestone." Not having previously communicated with Dr. Griffith on the subject, which perhaps I ought to have done, I was, as I said before, quite unaware that I was opposing the views he then entertained, when I proposed, in the paper I have mentioned, to class the Carboniferous Slate as well as the Yellow Sandstone as upper Devonian. Since that time I have been given to understand by palæontologists, but still, I must say, hitherto in a rather vague and undecided way, that the fossils* found in the Carboniferous Slate are Carboniferous fossils. If when they all come to be examined and determined by adequate palæontological authority (of which, I grieve to say, we are just at present completely destitute in Ireland, or at all events in Dublin), that this is so, of course the palæontological characters must be allowed to override the physical ones. The same will be true of the Yellow Sandstone if the same decision be arrived at as to its fossils: in which case it will be impossible for any hard line to be drawn on our maps between the Carboniferous and Old Red rocks of the south of Ireland; but the colours representing the two ought to be shaded into each other. On that point I will only say that they have a so-called "Yellow Sandstone" in Scotland, which the Scotch geologists all speak of as the upper part of their Old Red Sandstone; and that almost the last letter which I received from my lamented friend, Edward Forbes,† informed me that he had found

* There will probably be little doubt as to the Carboniferous character of the fossils to be found in certain flaggy limestones, and shales interstratified with calcareous courses, and rarely exceeding 100 feet in thickness, just below the main mass of the limestone at the Hook Point, at Clonea Castle, near Ardmore, and other places, but that does not necessarily settle the nomenclature and classification of the great mass of the "Carboniferous Slate," some thousands of feet thick, in the western part of the county of Cork, though I believe the fossils throughout are of a Carboniferous character.

† As this letter contained his latest views on this subject, although written hastily, in answer to one of my own containing questions upon it, it will perhaps be advisable for me to lay before you the following extract from it. Its date was the 26th of October, 1854, but fourteen days before he was seized with that illness which was to prevent all future intercourse in this world:—

"I went yesterday, with Mr. Maclaren, to look at Hugh Miller's collection. Of course I paid particular attention to his Old Red Sandstone, and, to my surprise and

in the collection of Hugh Miller, from the same locality as some of the fish which have become classical characteristics of the Old Red Sandstone, a fragment of a fern which he believed to be identical with the *Cyclopteris Hibernicus* that occurs so abundantly and frequently throughout the Yellow Sandstone of the south of Ireland, from the eastern part of Kilkenny* down to Bantry Bay. My own opinions on this question now are the following: That Dr. Griffith, whom I have so long looked up to as one of the fathers of our science, was right in separating the rocks of the western part of the county of Cork into three divisions: Carboniferous Slate, Yellow Sandstone, and Old Red Sandstone; that in spite of the physical difficulties, the Carboniferous Slate is probably a true Carboniferous rock; that the Yellow Sandstone *of the south of Ireland* may be still doubtful, but that the balance of evidence is in favour of its being considered† Upper Devonian, or the transition rock between Devonian and Carboniferous, but that these questions of classification, if they are to be determined palæontologically, must be left to professed

delight, beheld among his plants of that formation a Scottish specimen of what seemed, almost without a doubt, *Cyclopteris Hibernicus*. Miller did not know what it was, nor see its bearing; so, before I told him, in order to get the better evidence, I questioned him about its locality. He states that the specimens in question are from the upper Old Red of the neighbourhood of Dunse, in Berwickshire, and that along with the fern occur fishes, Ptericthys and Holoptychius. Now as the Berwickshire coal-fields are said to be below the mountain limestone, and to be equivalents of Maclaren's calciferous sandstone (= Carboniferous Slate), which distinctly overlies the 'Yellow Sandstone' of Scottish geologists (i. e. the upper Old Red), but conformably, and I believe with a passage, we seem to get a gleam of sunshine available for our purpose.

"I know that Griffith, at Belfast, made the north of Ireland equivalents of the Carboniferous Slates the type of his 'Yellow Sandstone.' But since the term is applied here to the equivalents of the Kiltorkan series, and is very applicable, might he not be induced to reserve it for this upper Old Red, i. e. the top of the Devonian?

"Maclaren's 'calciferous sandstone' should be kept in mind in any nomenclature. It was a shrewd and well-drawn distinction of his, published many years ago."

* I always considered the Cyclopteris and the Anodon found at Knocktopher to be in the Yellow Sandstone, though in the lower part of it. They have *both* been since found at Tivoli Villa, close on the Glanmire road, a mile or so east of Cork, and the fern at many other places.

† The Yellow Sandstone of the east of the county of Cork is in some places crowded with *Cucullæa Hardingii*, *Avicula Damnoniensis*, and in others with a minute Cypris, which may be more or less closely allied to the characteristic Devonian *Cypridina serratostriata* mentioned by Sir R. I. Murchison in his "Siluria," p. 264.

palæontologists to decide; and therefore I, for one, declare my own incompetency to hold any independent opinion or give any authoritative decision on that part of the subject.*

Having thus put myself in a right position, I may proceed to remark on the great interest of the more immediate subject of Dr. Griffith's paper—the relation, namely, of the deposits of copper to the beds. Messrs. Willson and Wyley, of the Geological Survey, when they came to examine the county, were at once struck with the manner in which the mines of the south-west of Cork followed the outcrop of a certain set of beds; and I am glad that Dr. Griffith has now put on record his own long-preceding recognition of the same fact. The deposits of copper and lead, whether they be true lodes, or whether they be metalliferous beds, are almost always found within a certain distance of the boundary of the Yellow Sandstone, either on one side or the other; and this not merely in one line of strike, but throughout the various undulations of the rocks, wherever the Yellow Sandstone crops to the surface, copper or lead, or both, have been found in the neighbourhood. There would appear from this circumstance, then, to have been an original sedimentary deposition of copper and lead ores contemporaneously with this set of rocks, whether those metallic minerals have been left in their original state, or have been subsequently segregated into cracks and fissures, and now occur as true lodes, or as lode-like beds. It is obvious that in a district where the beds are so highly inclined, mostly vertical, or nearly so, fissures may have taken place along the planes of the beds as well as across them, and thus we may have a true lode, although it be regularly interstratified between two beds. Although, in consequence of this general diffusion of the minerals, the chances seem to be against any very rich accumulation of them in one spot, yet it is possible that this very fact would, if the district were carefully studied with a view to such an object, lead to good results in throwing light on the hitherto obscure theories of

* In my paper mentioned before, it will be seen that the only point of classification to which I address myself is the union of the Carboniferous Slate and Yellow Sandstone, in consequence of their physical blending. I took it for granted that the Yellow Sandstone of the south of Ireland, which is physically part of the Old Red Sandstone, must belong to it, and be called therefore Devonian; and I thought the physical union between the Carboniferous Slate and the Yellow Sandstone also too intimate to allow of their separation into different formations.

the origin of mineral veins. This is one of the many subjects which it is impossible for the Geological Survey to take up, for want of time, tied down as we are to covering as many square miles as possible per annum of the great six-inch map, with accurately observed data as to the character and position of the rocks. It is one on which we can only hope to afford the inquirer the necessary preliminary information for commencing his researches, and is, therefore, one of those many investigations which, as pointed out by my esteemed predecessor, Dr. Ball, in his Address, are open to the labours of individual geologists, without any fear of those labours being forestalled or made of none effect by the publications of the Survey.*

In the next paper, by Professor Haughton, "On the Mining District of Kenmare," being No. 3 of his "Geological and Statistical Notes on Irish Mines," this subject is continued. I would first say how entirely I agree with Professor Haughton in his preliminary remarks on the necessity of combining the practical knowledge of the miner, the quarryman, and the farmer, with the theoretical science of the geologist. Such men are themselves geologists as far as their opportunities of observation have extended. They have all their lives been practising geology, as M. Jourdain had been speaking prose, without being aware of it.

With the mining and mineralogical details of this paper, as with those of Professor Haughton's previous paper of this series, I shall not meddle. Professor Haughton, however, mentions two geological facts, namely, the inverted position of the beds, the axis of the inverted fold inclining to the south, which is by no means an unexampled occurrence in the south-west of the county of Cork; and the calcareous beds below the actual limestone, which are likewise of frequent occurrence in the south of Ireland. These, when they occur in the red slates, are analogous to the cornstones of the Old Red Sandstone of Shropshire, &c. The occurrence of magnesia in them, as mentioned by Professor Haughton, was, however, new to me. The most remarkable circumstance, however, in the geological structure of the Kenmare Valley, although it is not one that can be discovered by an examination confined to that district, is the almost

* It is obvious that it would be impossible for any officer of the Survey to follow out any particular line of investigation requiring freedom of locomotion and independent action, because each and all are necessarily restricted to the particular district in which we may be at work.

entire absence of the Carboniferous Slate. The Carboniferous Slate, with a thickness of at least 1500 feet, is interposed between the Carboniferous Limestone and the Old Red at Carrigaline, near Cork Harbour. The Old Red and the Carboniferous Slate range thence uninterruptedly to the westward to Bantry Bay, where the Carboniferous Slate is at least 3000 feet thick, having no solid limestone above it, but only some calcareous bands, of a foot or two in thickness, interstratified with its upper beds. This is on the south side of the anticlinal which runs from the north side of the city of Cork to Glengariff; while at two places, on the northern slope of that anticlinal, namely, at Macroom and at Kenmare, solid limestone is found just above the red slates of the Old Red Sandstone, with not much room for any Yellow Sandstone, and with none at all for more than a score or two of feet of Carboniferous Slate to be interposed between them. This overlap, or partial unconformity of the Carboniferous Limestone to the Carboniferous Slate, is one of the strong physical facts alluded to before, which would lead us to unite it with the Devonian rocks below rather than with the Carboniferous rocks above.

We have next a paper "On the Limestone Troughs of Ardmore and Lismore, county of Waterford," by Charles P. Cotton, Esq., and one "On the Carboniferous Limestone of Midleton, county of Cork," by William J. Welland, Esq. These, I believe, are each the first production of their respective authors, and to be looked at, therefore, rather for the promise they give of future excellence than for their own intrinsic value. They both show evidence of careful and accurate observation, and powers of succinct description, which lead us to expect future contributions of still greater importance from these gentlemen.

Mr. Triphook's paper, "On the Occurrence of Sulphate of Barytes in the South-west of the county of Cork," contains an account of some points of interest in the barytes mine between Roaring Water and Dunmanus Bays, and some hints as to the possibility of hereafter extracting sulphuric acid from the sulphate of barytes. The description of local facts, and the discussion of practical questions connected with our science, must always be of value to us; and though I believe patents have formerly been taken out for extracting sulphur from sulphate of barytes, and converting it into sulphuric acid, without success in a commercial point of view, we may hope that more profitable methods may be hit upon hereafter.

Of Professor Galbraith's paper on the "Analysis of Felspar" I have already spoken; and we then come to Professor Haughton's paper "On the Evidence afforded by Fossil Plants, Corals, and Mollusca, as to the boundary line between the Devonian and Carboniferous Rocks," of which we have only had before us the first part, that relating to the plants.

I must, in reviewing this Paper, object, *in limine*, to the second principle laid down in it: namely, that when one or other of two groups of conformable rocks do not contain fossils, we draw the line of separation at the point where fossil remains commence or disappear.

Such a principle* would place negative evidence in the same rank as positive evidence, and, if carried out to its full extent, would lead to the intercalation of a number of new groups between our present formations, both vertically and laterally.

Our boundary lines depend on the union of lithological and palæontological evidence, and although where we have sufficient of the latter it may be allowed supremacy over any amount of the former, yet our boundary lines must be drawn primarily on *physical and lithological evidence alone*, irrespective of fossils, which are merely to be used afterwards, as testing the value of those boundary lines, and enabling us to group the different stages of rock uniting or separating them, as the case may be.

Instead of the principle laid down above, I think all geologists would be rather inclined to adopt its converse: that in case of two conformable sets of rock, a fossiliferous and unfossiliferous one, coming together, the two should be classified together as one group or formation, unless there were good physical or other reasons to the contrary.

Applying that principle to the case of the south of Ireland, I would say that there is no palæontological reason, *in Ireland*, for separating the Old Red Sandstone itself from the Carboniferous formation, and no lithological reason, *in the south of Ireland*, for separating the Old Red Sandstone (so called) even from the Carboniferous Slate.

It must always be borne in mind that the boundary line between

* I do not here speak of the necessity of drawing a line at the base of the whole fossiliferous series, if such a base exist, and separating from it all the azoic rocks below it, where their azoic character is fully demonstrated.

the Devonian and Carboniferous formations is to be looked upon as a minor one, and by no means of the same value as that between the Silurian and Devonian. The Palæozoic rocks may be divided into two, the Upper and the Lower; the boundary between the two being drawn at the top of the Silurian. The palæontological difference between the Devonian and Carboniferous, therefore, may be likened to that between the Wenlock and the Ludlow rocks, many fossils ranging through both, while some only are distinct, and even that distinction is only a local one, since in other localities there is a physical blending, and possibly also a palæontological one. Still, when the distiuction is proved anywhere to exist, it should always, if possible, be drawn, and must always be theoretically understood, even where it cannot be practically exhibited. The difficulty of drawing these minor boundaries will often be great in proportion to the completeness of the series of rocks and fossils in different localities; and nothing but the most minute and exhaustive examination will enable them to be finally determined.

On the latter part of Professor Haughton's paper I would only express my satisfaction at seeing him inclined to enter on palæontological investigations, since that in which our Society is most deficient is a good palæontological observer and authority; but without venturing to pass any opinion of my own on the correctness of his generic and specific determinations of fossil plants, I would quote, for the guidance of us all, the following passages from the last year's Address of Professor Edward Forbes to the Geological Society of London:—

"The search after and description of fossil plants has been actively prosecuted on the Continent. . . . . As contributions of facts towards a future understanding of fossil botany, these papers and figures are welcome and valuable; but as palæontological data for the service of the geologist, the use and appreciation of them require the greatest judgment and caution. The vegetable unit in lists of extinct beings is of far inferior value to the animal unit, and conclusions respecting the age and affinities of formations drawn from the fragments of an ancient Flora should always be put forth as problematical and provisional. . . . . Every botanist knows how difficult is the attempt to determine species of living plants from imperfect fragments, ... yet such are the materials from which, in nine cases out of ten, the

describer of fossil plants constructs his species. Would that the warnings so often and admirably pronounced within our walls by my most able friends and fellow-members Dr. Hooker and Mr. Charles Bunbury, were heard by some of the palæo-phytologists of Germany."

GEOLOGICAL SURVEYS.

Having thus discharged the rather invidious and not very welcome duty of criticising the productions of my fellow-members, I think it possible that it may not be entirely devoid of benefit to our science or of interest to the Society, if I take advantage of this opportunity to lay before you my own opinions of the nature and utility of national geological surveys. In doing this I shall endeavour, as far as possible, to divest myself of all prejudice derived from my official position as Local Director of a branch of our own national survey, and look at such undertakings from the point of view occupied by an independent geologist.

There is this difference at once obvious between geological and topographical surveying. In the latter, the surveyor has to lay down correctly on his paper the form and outline of all the objects which he sees that are capable of being delineated on the scale he has to employ: all the roads, towns, lakes, rivers, seas, or these together with all the houses, and fields, and ponds, and quarries, &c., according to circumstances. All this can be done according to certain simple rules very easily learned, and almost as easily reduced to practice. The rules could be learned, and the practice acquired by ninety-nine men out of a hundred you meet walking along the street. The difficult part of the process, that which alone requires great scientific knowledge and skill, is either the preliminary part of the operation, the measuring of the base, the laying out of the system of triangulation, the fixing the principal points, or the arranging of the methods by which these shall be correctly projected and laid down so as to retain correctly their relative situations in the subsequent combining of the detailed work of different surveyors, so as to get each exactly into its right place. I am not now, however, speaking of these higher parts of a great topographical survey, but of the filling in of the detail, which is almost entirely a mechanical business, requiring the surveyor simply to correctly measure and delineate *that which he sees.*

In geological surveying, however, it is necessary that every man should be able not only correctly to delineate and describe that which he sees, but also that *which he does not see;* or, at all events, that he should be able to assign a limit of error beyond which his delineations cannot wander from the truth. This necessitates a capability of arguing logically from certain data, of drawing conclusions from certain more or less known facts; in brief, the possession of an amount of judgment and acumen which I, at all events, may very safely say *is not possessed* by ninety-nine out of every hundred men we meet in going along the street.

In topographical surveying, the things to be delineated are all exposed upon or above the surface of the earth; in geological surveying, certain things are seen at the surface, and the continuation and connexion of those things beneath the surface are inferred with more or less certainty, or with more or less probability, according to the circumstances of the case. There is no room for any mere mechanical workman, but every man must combine his own details, and make them harmonize with those of the general results of his fellow-labourers if he have them, each and all forming a critical estimate of the evidence obtained in different localities.

In examining, therefore, a geological map of a country, and wishing to know the amount of trust that may be accorded to it, two questions arise in the mind:—

1st. Did the surveyor thoroughly examine and explore *everything* that was exposed to his observation? did he collect *all the data that it was possible to collect* at the time of his examination?

2nd. Did he reason correctly, and draw correct inferences from those data?

The value of a geological map may be vitiated by a failure in either of those two conditions. The geological surveyor may have collected a vast number of data with the most perfect accuracy, and he may have drawn perfectly correct conclusions from them, and yet his results may be all false, by reason of his having neglected to visit some obscure, difficult, out-of-the-way quarry or ravine or cliff, which was either unobserved, or was not thought worthy of the trouble of a visit, while in that neglected spot, perhaps the solitary exception, the only spot not visited in the district, lay the clue to the whole structure of the country, the key without which it could not be opened, nor the knowledge of its mystery obtained.

I speak here from personal experience,—experience, I believe, shared by all practical geologists.

On the other hand, every square inch of the district may have been most diligently and honestly examined and explored, and yet, either from want of acumen on the part of the observer, or from want of practice, or of knowledge of some particular fact, or some branch of science not acquired by him, or, perhaps, from never having explored a similar district where the facts were more plainly and distinctly exhibited, the whole conclusions may have been wrongly drawn, and the map, instead of being the picture of nature, may be merely a representation of the distorted image in the observer's mind.*

Again, without being utterly and hopelessly wrong, a geological map may, from either of the two causes mentioned above, or from a combination of both, partake of the character of a mere rough approximation only to the truth: it may give the general facts, while it may be quite untrustworthy as to the details.

* As an instance of something of this kind I may, perhaps, be permitted to give a personal example. I had once been working hard, for about five weeks, trying to understand and delineate on the one-inch map, a complicated bit of mountain ground a few miles south of Conway in North Wales. It was made up of interstratified slates, sandstones, and felstones, with large and irregular masses of intrusive greenstone, the exposed parts of each being frequent, but not continuous. Many a weary day had I climbed the sides, and clambered along the crags of a hill some five or six miles in length by two or three in breadth, and the highest peak of which was not more than 1800 feet above the sea, trying in vain to reduce to order the seemingly endless complexity of its structure; and having at length on the map as curiously complex a patchwork of incongruous colours and unnatural forms, as Punch, had he turned geologist, could have devised;—when, one evening, as, after a hard day's work, I was descending a steep bit of ground almost in despair at all my labour seeming to be thrown away, I hit upon the clue to a great fault or dislocation. I had only time then to verify the observation, but it gave me at once the solution of all the puzzle, and in two or three days I was enabled to map the whole district with as near an approach to accuracy as the scale of the map admitted of. The country was chopped up by a series of large parallel faults, that were quite easy to be seen when once the clue to one of them and its bearing were obtained, but which there was nothing to render *à priori* probable, and which could not have been discovered without that thoroughly exhaustive process of examination which I was enabled to apply to the district. I have ever since regretted, that in my haste and joy at acquiring a right notion I obliterated all my former work from the map which contained it, as I should have been glad to preserve it now as a curious instance of the contrast between laborious hypothesis and the simplicity of natural truth.

So far for the more obvious sources of error in geological surveying and mapping. In maps which are the result of the work of private persons, the degree of accuracy of course depends on the object the person had in view, and the means he had of obtaining it. For one man's object a rough outline map may have sufficed; another may have desired to make an accurate map, but the time and money at his command may not have been sufficient to enable him to do so. From private individuals any contribution to our general stock of knowledge and means of information must be thankfully received, without too strictly criticising the amount of the gift, unless undue credit be taken for it, and it be ostentatiously paraded as of very much greater value than it possesses in reality. The measure of leniency, however, which ought to be accorded to private benefactors is quite different from that which should be granted to public officers who are paid by the State for doing properly, thoroughly, and well, that which they have to do. That sentiment, Gentlemen, I feel quite sure will meet your cordial approval, and I accept it with all its consequences. Let us reduce it to a simple proposition.

A national geological survey should be conducted with the most minute accuracy possible to be attained.

No one will, I think, venture to impugn that proposition, and yet many would assent to it without rightly understanding it. The accuracy of a geological survey must almost entirely depend, first, on the accuracy, and secondly, on the size or scale, of the topographical maps the geologist has to work with. With inaccurate maps, of any size, it is impossible to do accurate geological work. But with correct maps, the accuracy of the geological work depends in large measure upon the scale of the maps, and it will be at once obvious that accurate geological work becomes more easy as the scale of the map is increased.

On maps of small scale, such for instance as an inch to a mile and *à fortiori* on less scales, it is difficult and often impossible to "fix" yourself; that is to say, to find out exactly where you are upon the map. Suppose you are in a quarry, or at a cliff, not marked upon the map, or in the centre of a number of fields, or on a bare hill-side, with no object near you that is marked upon the map, it is often difficult or impossible, even with the aid of a prismatic compass and protractor, to find the position of that quarry or cliff with anything like precision. And yet upon the exact position of that

spot being known may often depend the accuracy of a geological boundary, or fault, or other feature, on which subsequently questions may arise that may, perhaps, have important practical or theoretical bearings. In consequence of an erroneous position being assigned to that cliff or quarry,—by no fault of the geological observer, who may have done the best he could to fix it correctly,—all his work may be vitiated and thrown out; and even if he detect the error, its cause may long remain unknown to him, and give him endless trouble to ascertain.

If, however, the geological surveyor have maps of a larger scale to work on, such as the six-inch maps of the Townland Survey of Ireland, all these sources of error are greatly diminished, and practically almost done away with. On these maps not only are the houses and such objects marked, but every fence, every stream, every natural and artificial object that is capable of being drawn as occupying a definite place upon the map, is so delineated. Every quarry that existed at the time the map was made is marked upon it. In enclosed ground every spot may be "fixed" quite accurately by reference to the surrounding fences; on wild hill-sides there is hardly a space as large as the hand that has not some crag, or rock, or little stream, or conspicuous peak, marked upon the map, so that any other spot may be easily found from them by a simple bearing and measurement.

The second general proposition then, regarding national geological surveys which I shall venture to propound is, that the largest and most accurate map that can be procured shall be used for the reception of the geological work. This proposition, however, also requires some explanation, since it is possible to have maps on too large a scale for ordinary geological work as it is at present understood, though not, perhaps, for what will be required hereafter. I would, however, for the present, modify the proposition above given into the following. The best scale for a map to be used in a national geological survey is one which, exhibiting all the natural and artificial features mentioned before, *allows of the registering on the map itself, by the use of words, symbols, and colours, all the geological data that can be observed at the time the survey is made, and yet keeps them within as small a compass as possible.*

By the adoption of such a map, and the use of a skilfully devised system of symbols, and colours, and written descriptions, it is pos-

sible to construct a great public document of much value in various ways. I do not by any means wish to propose the engraving of all these data, and the publication of a geological map on the six-inch, or other similarly large scale. What I would insist on is the necessity for having this large map for the field-work, and for the construction of a great public document of reference. The publication of the results would be best effected on a much smaller map, say on one of an inch to a mile, which would enable us to take a general view of the structure of a country, and see the relations of one part to another. Still smaller maps, indeed, become necessary, as we wish to carry out still further generalization over wider districts, but we may safely leave it to private enterprise to construct these smaller maps, after the one containing the results of the national survey has been published. Private enterprise, however, could never undertake the detailed examination of a whole country, and the collection and registration of all the *observable data* which I consider the peculiar duty of a national survey.

The possession of such a document would give us many advantages, the most obvious of which is, that by reference to it the correctness of the conclusions drawn from it and published on the smaller map may be tested, and if error be introduced it may, with comparative ease, be discovered, whether it arose from the insufficiency of the data, from their having been wrongly described, and if so, which of them, or from illogical reasoning.

In such a document we should have preserved, *on the map itself*, a large part at least of the knowledge of detail and of facts, which, if a smaller map had been used, would have existed only in scattered note-books, or, perhaps, only in the head and memory of the observer, and thus in either case would have soon been lost. Another advantage, especially if the map be contoured, is the facility with which detailed sections, in any direction, giving the true form of the ground, and the true inclination and position of the beds below the surface, may be constructed from it.

There are, however, still greater advantages to be derived from the use of a large scaled map, one of which is its capability of being used for purposes of practical utility. If all the observable data be registered on such a map, and copies of that map be carefully preserved and arranged, we have the materials for the formation of a "mineral report" on any district that the land-owner, intended purchaser, or other interested person, may desire a report upon.

In Lancashire, one of the few English counties in which the six-inch scale has been adopted, recent inquiries enable me to state, that it has been found of the greatest practical use in coal-mining. I have been assured that many of these maps are used in different collieries for the purpose of laying down a reduction from the working plans of the different coal seams, and thus acquiring accurate general notions of the state of the works from time to time. If the coal-owners had access to some general geological map on that scale, and could obtain copies of it, showing the outcrops of all the coals, and the position and direction of the different faults and dislocations, it is obvious that their present utility would be greatly augmented.

As an instance of the great practical value of geological maps, I may point to the fact of Dr. Griffith having found it advisable to have a reduction of his large Geological Map of Ireland* prefixed to his book of "Instructions to the valuators and surveyors for the uniform valuation of the lands and tenements of Ireland." The following is an extract from the passage in the instructions having reference to this map. After having given a succinct description of the different kinds of soil, and their different degrees of fertility on the principal geological formations of Ireland, the Instructions go on to say:—

"It is of the utmost importance that the valuator should carefully attend to the mineral composition of the soil in each case, and a reference to the Geological Map will frequently assist his judgment in this respect, the relative position of the subjacent rocks having been determined upon sectional and fossiliferous evidence. He should also carefully observe the changes in the quality and fertility of the soil near to the boundaries of different rock formations, and he should expect and look for sudden transitions from cold, sterile clayey soils, as in the millstone grit districts, into the rich unctuous loams of the adjoining limestone districts, which usually commence close to the line of boundary; and similar rapid changes will be observed from barrenness to fertility along the boundaries of our granite, trap, and schistose districts, the principle being, that every change in the composition of rock tends to an alteration, beneficial or otherwise, in the quality of the subsoil, and also of the active soil."

* Dr. Griffith has this day placed upon our walls a copy of the new edition of this most valuable map of his,—a map for which he last year received the highest honour in the power of the Geological Society of London to confer.

The Instructions then give a Table of the analyses of different rocks, and also of the "Classification of Soils with reference to their composition," followed by a short description of their several kinds: altogether forming quite a manual of geological instruction for the valuer of land, and a model of the application of geological science to practical purposes.

The testimony of such an authority to the practical value of geology must be very gratifying to us. It is at once obvious that if the geological boundaries and constitution of the rock below be of such importance to the person wishing to set the true value upon land (and I have Dr. Griffith's authority for stating that the beneficial results of their attention to these points has been in practice most remarkable), of how much greater and more lasting importance must it be to those whose lives are spent in the cultivation of land, and whose income depends on that being done in the best manner.

Now, it has often occurred to me that a national Geological Survey on six-inch maps, or other large scales, if properly done, might be made to serve other uses than the mere accurate construction of a general geological map, such as is most useful to geologists for theoretic and scientific purposes. A system might be adopted of giving to any applicant, for a slight fee sufficient to cover the expense, a copy of the map of any district on the large scale, completely coloured, with one or more sections across it, and a written explanation sufficient to point out the nature of the different rocks at or near the surface of the ground, and the possibility of the occurrence of any large quantity of any mineral substance beneath the surface, the depth at which it will be found, and the position in which it will probably lie.

Such reports, drawn from the public documents, would be often likely to be more accurate than private surveys even on a much larger scale, inasmuch as the whole of the neighbourhood having been examined, with equal minuteness, any particular portion of it will be more thoroughly understood, and the possibility of error more completely guarded against.

Looking forward, as I do most confidently, to the time when no possessor of land will be content to be without a geologically coloured map of his property and its neighbourhood, and a report upon it, I would keep this future use of the great public document steadily in view.

For these and other reasons, I would lay it down as a rule to be strictly adhered to on a national Geological Survey that a map on the scale of at least six inches to the mile be used for the field-work when attainable, and that *every part of that be thoroughly and minutely worked out*,—that even in wide and barren districts composed exclusively of one particular kind of rock, such as granite or Old Red Sandstone, every square foot of ground be examined, and every exposure of rock carefully marked upon the map; if for no other reason, yet for this, that a document of reference should exist, which, on any occasion that might arise, should afford a ready means of proof that no other rock was to be found there. It is, moreover, impossible for any person to pronounce *à priori* with respect to such a district, what may or may not be found in any particular part of it, until *it has been examined.* In short, a national Geological Survey should be done in such a manner as to suffice once and for ever, and not require to be done over again in the course of a few years.

It is, however, quite clear that to carry on a survey in this accurate and complete manner is a work of time. The number of trained observers that can work together in combination must always be comparatively small: delays will arise from the difficulty of getting quarters in wild districts, from uncertainties of weather, from time lost in training new hands to supply the vacancies that will from time to time occur,—so that the work, if carried on in the way it ought to be, must necessarily appear slow. Slow let it be, in my opinion, provided only it be sure, since, in geological investigation, more perhaps than in any other practical operation, is the old adage verified, "the more haste, the worse speed."

Although the accurate working of a large-scaled detailed map may appear slow, however, it is not slow in reality compared with an *equally accurate* working of a small-scaled map. Having had experience of both, I can confidently assert that I have been much longer working out the details of a complicated tract on the small scale than I should have been on the large one. I have had, in fact, to construct in my imagination, as it were, an enlarged geological map, and then to lay down a reduction of that ideal model as nearly as I could on the small map, a much more tedious as well as more uncertain process than that of patiently registering on the spot the actual data observed, and letting the results work out themselves.

My reason, Gentlemen, for bringing before you my own notions

of what a national Geological Survey ought to be, is that not only the general public, but even, I believe, some geologists, are not prepared to acquiesce in the desirability or utility of so minutely accurate and detailed a survey as that of which I have been speaking; and I wish to place this subject under the consideration of yourselves and other geologists, in order that some definite public opinion should be formed on it in the geological world in general.

When the great Topographical Survey of Ireland was commenced, the plans conceived by General Colby were thought too gigantic, and the minute accuracy required, much too strict and exacting; and so strongly was this opinion impressed on the minds of influential men, that a suspension of his originally devised scheme took place.* It was, however, soon found advisable to return to the system of sound, accurate, and perfect work, and we may congratulate ourselves that the admirable plans of that eminent man were ultimately carried out, although they may have seemed at the time greater and more costly than was immediately required.

Similarly, I would always wish to see a national Geological Survey carried on with reference not so much to what may be thought our immediate requirements, as to the wants and requirements of the future. It ought to be in advance of its time, in order that in a few years it may not be found to lag behind it. It ought to contemplate geology and its practical uses, not so much as they exist now, as foreseeing what they will be in the next and future generations.

You may perhaps, Gentlemen, be inclined to ask me how far the Geological Survey of Ireland will be in accordance with the high aspirations I have been putting forth. To this question, I may answer that it is one thing to form a great ideal model, and another to attain to its perfect execution. I hope that the future will prove our work to be not greatly below the standard of merit which I think ought to be attained, though from a variety of circumstances I fear it must in many instances fall short of it. One drawback has hitherto been the want of sufficient means to do our work properly; but I am happy to say that that impediment has been to some extent removed during the past year. Our staff of field geologists has been raised to six, and when our younger colleagues shall have ac-

* See "Correspondence respecting the Scale of the Ordnance Survey, &c." submitted to Parliament in 1854, "Blue Book," p. 4.

quired the requisite skill and practice, we may reasonably hope to do more than double our past rate of progress.

Still, even now, we have to choose between apparent slowness and a hasty and imperfect execution of our work; and it has been very difficult for us to avoid falling into the latter error in endeavouring to satisfy the public requirements for greater celerity. We are compelled to overcome our difficulties as best we may with the means afforded us, hoping that when a better day comes, and the value and importance of geological work is more truly appreciated, we may be found to have done our best, and to have been not altogether useless in our generation.

As regards our progress, in addition to the counties of Dublin, Wicklow, Kildare, Carlow, and Wexford, of which coloured index maps have been published, we have completed on the six-inch maps the survey of the county of Waterford, nearly the whole of Cork, two-thirds of Kilkenny, and the parts of the adjacent counties which deeply indent those named. We have, in short, completed a broad band of country, extending from Dublin along the whole south-eastern and southern coasts, and our line of operations now extends from Berehaven on the northern shore of Bantry Bay by Kenmare and Millstreet to Mallow.

In expectation of having the one-inch sheet map of Ireland within a reasonable time on which to publish our results, we have not published an index of Waterford, although it has been for some time finished. You will recollect that I exhibited to you about fourteen months ago a coloured copy of one of these one-inch maps, including the northern part of the county of Wicklow, and that I then anticipated its immediate completion and publication.

Some delay has occurred in the Ordnance Department, from which we receive these maps, and where the geological lines are engraved for us. I believe this delay has arisen partly, perhaps, from the pressure of other public matters, especially during this time of war, but principally from the difficulty found in organizing a good staff of engravers, who should work with the same uniform amount of delicacy and precision of execution. Captain Leach informs me that they have only just succeeded in overcoming this difficulty, and we may hope now, I believe, for the immediate publication of the sheet of the one-inch map containing the principal part of Wicklow, and for its being rapidly followed by those of Wexford

and the other parts of the south of Ireland of which the Geological Survey is complete.

Gentlemen, my task is finished. It remains for me only to thank you for the honour you have done me in placing me in this Chair during the last two years, and to acknowledge with gratitude the undeviating kindness and assistance I have received from the Council and all the officers of the Society in performing the duties of the office. I shall ever cherish the recollection of your favour given to one who came among you a stranger to almost all of you, and who now hopes he may look upon all of you as his friends. It has been one of the most gratifying incidents of my life, and will form a memory which nothing can rob me of as long as that life endures. I now resign the Chair to Lord Talbot de Malahide, a nobleman whose private worth is well known to you all, and who makes the most noble use of rank and fortune, that, namely, of devoting them to the purpose of furthering the progress of Science and of Art both in his native country and elsewhere, and who, as he has previously presided over an Archæological Society, may be said to be taking the next natural step backward into past time, in coming to preside over our investigations of a still more remote antiquity. Under his auspices we may confidently look forward to an increase in the number of our members, a still greater energy in their labours, and an enlargement alike of our individual and collective utility and reputation.

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